9.7 ANALYSIS OF EFFECTS

The effects of the RPA are evaluated with respect to action-area biological requirements in Section 9.7.1 and with respect to species-level biological requirements in Section 9.7.2. These sections parallel those used to evaluate the proposed action in Section 6. Additionally, in Section 9.7.3, the effects of the RPA are compared to effects that would probably occur as a result of breaching four Snake River dams. This comparison is included because dam breaching is an alternative that was specified for consideration in the 1995 FCRPS Biological Opinion, and it is the main alternative to the RPA that the Federal agencies have considered (Corps 1999c). It is also included because Section 9.5 describes breaching as a likely alternative action if the status of stocks has declined and/or the RPA is not as effective as expected, when assessed through the mid-point evaluation process. This analysis supports the elements of the RPA that require continued engineering and other preparations for possible future breaching.

9.7.1 Effects of RPA Measures on Action-Area Biological Requirements

As in Section 6.2, NMFS first evaluates the effects of the RPA within the action area. Effects are evaluated with respect to juvenile passage survival, adult passage survival, transportation, and various aspects of critical habitat within the action area.

9.7.1.1 Juvenile Salmonid Passage

Juvenile passage routing and survival are evaluated with respect to the various routes of passage at FCRPS dams. This section emphasizes changes from the proposed action that are expected from implementation of the RPA.

9.7.1.1.1 Turbine Units. Significant numbers of listed juvenile salmonids will continue to pass through FCRPS powerhouse turbines even with the relatively high proportion of fish passage through alternative routes (e.g., spill, bypass systems, and transportation). Previous FCRPS Biological Opinions (1995 and 1998) have required operation of turbines within guidelines that are expected to reduce mortality of juvenile migrants passing through turbines. These opinions also required investigations of juvenile and adult turbine passage mortality and investigation of turbine designs that reduce this mortality. Evaluation of a new turbine design using a minimum gap runner at Bonneville Dam has indicated a small but positive improvement (0 to 3%) in juvenile passage survival compared to the older runner design. These results are preliminary, and future evaluations are necessary before survival improvements can be statistically quantified.

This RPA calls for research to answer these questions. In addition, this RPA includes the following:

1. Investigations to improve fish survival in the tailrace

2. Examination of the potential fish survival benefits of operating minimum gap runner turbine units at or beyond the current guidelines of turbine operation established to maximize fish survival

3. Removal of unnecessary obstructions in the high-velocity areas of the turbine

4. Periodic index testing of turbine families to ensure that the operating guidelines reflect current conditions

These studies will provide better understanding of the complicated interaction between fish survival and turbine design and operation. This knowledge will probably lead to improved turbine design and operation to benefit fish survival. Considering the information available to date, NMFS expects that installation of minimum gap runners at the Bonneville Dam First Powerhouse would produce a 2% improvement in turbine survival at that project. Therefore, juvenile passage survival through the turbines at Bonneville First Powerhouse is expected to increase for both yearling spring and subyearling summer and steelhead migrants from 90%, under the current action (Appendix D, Tables D-1 to D-3), to 92% under the RPA (Appendix D, Tables D-4 to D-6).

9.7.1.1.2 Bypass Systems. The RPA is expected to increase FGE and bypass system survival at many of the FCRPS dams. The following section lists the expected increases at each dam for yearling spring migrants and subyearling summer migrants. The values estimated under the current configuration and operations can be found in Appendix D, Tables D-1 to D-3. The passage estimates expected under implementation of the RPA measures that were used in the SIMPAS passage survival modeling are shown in Appendix D, Tables D-4 to D-6.

Lower Granite Dam. Yearling and subyearling chinook and steelhead survival rates are expected to increase from 98% under the current action to 99% under the RPA, with juvenile fish bypass improvements.

Lower Monumental Dam. Yearling chinook FGE is expected to increase from 49% under the current action to 78% under the RPA with installation of extended-length intake screens and new vertical barrier screens. Bypass survival would increase from 95% to 98% with juvenile fish bypass improvements and outfall relocation. Subyearling FGE would increase from 49% to 56% with installation of extended-length intake screens and new vertical barrier screens. Steelhead FGE would increase from 82% to 84%.

McNary Dam. Yearling and subyearling chinook and steelhead bypass survival is expected to increase from 98% under the current action to 99% under the RPA with juvenile fish bypass improvements.

John Day Dam. Yearling chinook FGE is expected to increase from 73% under the current action to 82% under the RPA with installation of extended-length intake screens and new vertical barrier screens. Subyearling FGE is expected to increase from 32% to 60% with installation of extended-length intake screens and new vertical barrier screens. Steelhead FGE is expected to increase from 85% to 94%.

Bonneville First Powerhouse. Yearling FGE is expected to increase from 39% under the current action to 72% under the RPA with installation of extended-length intake screens. Bypass survival is expected to increase from 90% to 98% with juvenile fish bypass improvements. Subyearling FGE is expected to improve from 9% to 35% with installation of extended-length intake screens. Bypass survival would increase from 82% to 98% with juvenile fish bypass improvements. Steelhead FGE is expected to improve from 41% to 85%. Bypass survival would increase from 90% to 98%.

Bonneville Second Powerhouse. Yearling FGE is expected to increase from 48% under the current action to 60% under the RPA, with improved intake flows and screen performance. Subyearling FGE is expected to increase from 28% to 40% with improved intake flows and screen performance. Steelhead FGE is expected to increase from 48% to 60% under the RPA.

9.7.1.1.3 Spillway and Sluiceway Systems. In several ways, the RPA improves the current juvenile fish passage spill program, as defined in the 1995 FCRPS Biological Opinion and the 1998 Supplemental FCRPS Biological Opinion. The RPA includes:

- Implementation of 24-hour spill at Lower Monumental Dam
- Evaluation of 24-hour spill at John Day Dam
- Evaluation of raising the daytime spill cap at Bonneville Dam
- Reduction of 24-hour spill at The Dalles Dam

The evaluations at John Day, The Dalles, and Bonneville dams may lead to additional changes in the spill program as the study results are assessed and implemented. These changes may occur as early as the 2002 spill season, but may be limited by transmission system constraints that will be addressed no later than 2005. These changes are expected to improve inriver survival of all juvenile salmon migrants by reducing passage through turbines. Decreased predation is also anticipated as a result of reduced juvenile residence time in predator-rich forebays. In the case of The Dalles Dam, immediate survival benefits are expected as a result of spill reduction. Lower amounts of spill combined with improved spill patterns are expected to help reduce physical injury and predation in the river immediately below the spillway.

The FCRPS fish passage spill program improvements included in the RPA are estimated to result in a systemwide inriver survival rate increase of approximately 4% and 1% for yearling and subyearling migrants, respectively. These values represent a relative increase of 8% and 10% over the existing system inriver survival rate as estimated for each respective chinook stock.

These estimated survival rate improvements do not include further spill increases made possible through additional or modified spillway deflectors, nor do they include pool survival increases that may result when migrants spend less time in project forebays as a result of 24-hour spill. The greatest portion of the survival rate increase expected as a result of the RPA spill changes is expected at The Dalles Dam, where spill passage survival is estimated to increase approximately 8% to10%.

New structural measures to pass juveniles in surface water are under development at several FCRPS dams. These surface bypass efforts are expected to increase spill efficiency, reduce stress related to dam passage, and potentially reduce dissolved gas supersaturation levels. Increased spill efficiency means that water spilled for fish passage is more efficiently used or, in other words, more fish are passed per unit volume of water. Stress and delay are reduced when fish use surface routes through dams. Fish pass more readily through direct surface routes, whereas passage through deeper routes takes them longer. Reducing delays in forebays reduces juvenile exposure to predators. Reduction in predation and passage stress is expected to increase survival.

Current FCRPS project pool mortality estimates were reduced by 10% in the SIMPAS model runs under RPA conditions (Table 9.7-1) in order to characterize this expected survival increase. The expected 10% reduction in pool mortality is primarily based on reduced exposure of smolts to predators, both from project operations and predator control programs. This expected benefit is further explained in Section 9.7.1.5 below.

9.7.1.2 Adult Salmonid Passage

The RPA calls for a number of actions to better assess the effect of passage through the FCRPS hydropower system on adults and their spawning success, better account for adult losses, and identify and implement measures to reduce adult delays, injuries, and mortalities related to FCRPS passage. Aging adult fishway facilities will be updated, and spare parts for critical components will be procured to ensure proper operations during the passage season and avoid injurious facility failures. The identification and implementation of structural and operational measures are expected to reduce inadvertent adult fallback and related mortalities. For those adults that intentionally fall back, including downstream migrating adult steelhead kelts, identification and implementation of corrective operations and facilities will increase their survival. Identification of the cause of adult headburn will lead to corrective measures to reduce this source of injury to spring/summer chinook salmon. Potential benefits, including reduced water temperature, reduced passage delays, and improved gamete viability, for SR steelhead and fall chinook may be identified through the evaluation of Dworshak Reservoir cold water releases in September.

Table 9.7-1. Project and system survival of transported juvenile SR spring/summer and fall chinook salmon and steelhead outmigrants[1] under the RPA.

YEAR	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON	% Inriver Survival (LGR to BON)	% Inriver Survival (MCN to BON)	Prop. ESU Transported	% Total System Survival	% Total System Survival with D	
	Project Survival (% Dam + Pool Survival)													
SR spring/summer chinook salmon													D= 0.63	D= 0.73
1994	94.7	84.4	88.6	89.8	87.5	79.8	91.1	86.8	35.1	55.2	90.9	89.5	56.5	65.4
1995	91.7	89.0	95.1	94.0	94.5	87.0	93.6	90.9	51.1	70.0	43.4	67.7	52.0	56.2
1996	97.8	92.9	95.5	88.1	88.5	86.3	92.8	90.4	48.9	64.0	58.0	75.5	54.5	60.2
1997	92.4	94.4	92.5	90.1	90.4	85.1	91.7	89.5	45.9	63.2	51.7	69.9	51.1	56.2
1998	93.5	98.3	88.6	95.9	96.4	84.3	94.1	91.8	54.7	70.2	50.3	73.7	55.5	60.4
1999	94.9	95.1	95.1	95.3	95.9	87.1	95.7	94.7	61.9	75.7	51.8	77.9	59.1	64.2
6-YR Avg.	94.2	92.3	92.6	92.2	92.2	84.9	93.2	90.7	49.6	66.4	57.7	75.7	54.8	60.4
SR fall chinook salmon													D=0.24	
1994	No data collected in 1994.													
1995	69.9	89.5	81.4	88.8	83.7	77.4	89.6	85.1	22.4	49.4	62.8	62.3	15.6	
1996	52.8	90.3	79.8	88.4	84.1	76.2	89.2	84.4	16.2	48.3	47.1	46.9	11.8	
1997	41.4	60.4	67.5	66.9	58.8	40.8	71.7	57.4	1.1	9.9	31.7	31.1	7.5	
1998	60.0	78.8	92.4	88.8	84.3	77.3	89.6	85.0	19.2	49.6	52.2	51.9	13.0	

Table 9.7-1 (continued). Project and system survival of transported juvenile SR spring/summer and fall chinook salmon and steelhead outmigrants[1] under the RPA.

YEAR	Project Survival (% DAM + Pool Survival) LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON	% Inriver Survival (LGR to BON)	% Inriver Survival (MCN to BON)	Prop. ESU Transported	% Total System Survival	% Total System Survival with D	
1999	78.9	69.3	89.6	82.1	76.5	64.4	84.4	76.1	12.7	31.6	64.7	64.0	15.8	
5-YR Avg.	60.6	77.7	82.1	83.0	77.5	67.2	84.9	77.6	14.3	37.7	51.7	51.2	12.7	
SR steelhead													D= 0.52	D= 0.58
1994	91.4	87.6	93.6	91.6	89.7	83.3	92.3	89.0	42.1	61.3	89.9	88.3	46.0	51.3
1995	95.1	91.6	97.8	93.2	93.6	89.8	94.5	92.7	58.4	73.6	48.4	74.8	52.1	55.0
1996	94.2	95.1	96.6	89.9	90.2	87.6	93.1	91.3	52.3	67.2	59.3	76.8	48.9	52.4
1997	96.8	97.7	93.6	92.0	92.2	86.8	92.3	90.7	54.6	67.0	58.1	78.3	51.0	54.4
1998	93.5	94.5	92.4	90.2	90.6	85.0	96.1	95.5	51.9	70.6	52.1	73.0	48.4	51.5
1999	91.9	94.1	94.7	92.0	92.3	93.1	90.6	85.6	50.2	66.6	52.2	71.8	47.3	50.3
6-YR Avg.	93.8	93.4	94.8	91.5	91.4	87.6	93.1	90.8	51.6	67.7	60.0	77.2	49.0	52.5

[1] A range (1994 to 1999) of flow conditions was estimated using NMFS' spreadsheet model (SIMPAS). Values shown are estimates, based on juvenile survival studies rather than adult returns, and representing performance of mixed (wild + hatchery) runs. Spring/summer chinook salmon are yearling migrants; fall chinook salmon are subyearling migrants. Details on how these survival estimates were developed can be found in Appendix D.

Corrective measures at all the FCRPS projects which significantly reduce inadvertent fallback and the mortality associated with fallback through turbines are expected to increase the survival of all listed salmonid species that originate above Bonneville Dam. The analyses in the RPA concerning fallback, Subsection 9.6.1.6.2, estimate that with corrective measures spring/summer chinook and steelhead direct passage survival to Lower Granite Dam could increase by about 0.5%, while Snake River fall chinook direct passage survival could increase by 7%. Increased passage delay is also associated with fallback. Keefer and Bjornn (1999) reported that the median dam passage time for all seven dams studied in 1996 was higher for spring/summer chinook salmon that fell back at a dam one or more times. Conceivably, indirect delayed mortality and diminished spawning success could result from increased passage times due to fallback.

Corrective measures that significantly reduce the incidence of headburn could conceivably increase the survival of SR spring/summer chinook and UCR spring chinook by as much as 2% on average (see analyses in the RPA, Subsection 9.6.1.6.2).

A preliminary estimate of steelhead kelt abundance in the Lower Snake River in 2000 was 16,745 (Evans and Beaty 2000), which is approximately 22% of the total count of steelhead that passed upstream of Lower Granite Dam in 1999. The RPA requires studies to identify and implement measures to increase the survival of kelts so that the rate of repeat spawners will improve. Reconditioning, downstream transport, and reduced turbine entrainment passage alternatives will be evaluated.

Information from adult passage studies was used in the RPA analyses in Subsection 9.6.1.6.2 to arrive at preliminary estimates of 27% (1991) and 9% (1993) for spring/summer chinook salmon adult loss between Lower Granite Dam and the spawning ground or hatchery. While further studies will be needed to resolve the accuracy and determine the cause of these preliminary estimates, the significance of these loss estimates to recovery prospects cannot be overstated. Furthermore, mere arrival at the spawning ground does not guarantee spawning success. If spawning success is diminished during upstream passage, these adult loss estimates are conservative. Adult loss and diminished spawning success above Lower Granite Dam could be due to any number of causes suggested in the RPA, including delays, injuries, and elevated water temperatures experienced during passage through the FCRPS dams, or perhaps predation, illegal harvest, gillnet interactions, and disease. The RPA expects to better account for the sources of adult loss above Lower Granite Dam and downstream, assess spawning success, and implement identified measures to increase adult survival and reproduction.

Based on the foregoing reasoning and analyses, the RPA measures are expected to increase minimum survival estimates by at least 3% over the current condition minimum survival rates listed in Table 6.1-1 for SR spring/summer chinook, fall chinook, and steelhead that pass through eight FCRPS dams. For those species passing through four or fewer FCRPS dams, the expected survival increase from implementing the RPA is scaled down according to the number of dams. For example, for UCR steelhead and spring chinook that pass through four FCRPS dams, the

RPA measures are expected to increase the current minimum survival rate by at least 1.5%. For those species that pass only through Bonneville Dam, such as LCR steelhead and spring chinook, the expected survival rate increase is at least 0.5%. Table 9.7-2 summarizes the estimated minimal survival rates under current conditions and those expected under the RPA for the listed species. In addition to the increased passage survival rate, the RPA expects to identify, quantify, and reduce indirect mortality and diminished spawning success that may be due to passage through the FCRPS projects.

9.7.1.3 Water Regulation and Impoundments

BPA assessed the effects of water management measures specified in Section 9.6.1.2 using its Hydrosim hydroregulation model. The Hydrosim model simulates operations at the FCRPS and other Columbia basin projects to meet an array of purposes including flood control, anadromous and resident fish protection, projected energy loads, Columbia basin Treaty obligations, and other project-specific, non-power requirements. Hydrosim simulates operations for 14 time steps each year (10 months plus two time steps each for April and August) over a 50-year (August 1929 to July 1978) hydrologic record. Outputs of interest to NMFS include mean monthly discharge at various locations and end-of-month reservoir elevations for the major storage projects. A summer (June 30) reservoir refill priority was assumed in the modeling.

This approach to estimating the outcomes of alternative project operations implies that hydrologic conditions recorded in the past are reasonable estimates of future conditions. Hydrologic conditions are highly variable. The longer the historical period of record used, the more likely the simulation will capture the range of future conditions likely to occur. Although there is growing evidence that the earth's climate is changing, it is unlikely that such changes would substantially violate the assumption that future hydrologic conditions will be similar to past conditions during the 10 years this biological opinion will be in effect.

The base case model run placed priority on meeting the reservoir operating provisions specified in NMFS' 1995 and 1998 FCRPS Biological Opinions and USFWS' 1995 Biological Opinion on Kootenai River sturgeon. A summary of the base case (proposed action) model results are shown in Table 6.2-5. Subsequent modeling scenarios evaluated the effects of including VARQ and modified flood control curves, providing deeper reservoir drafts at selected FCRPS projects, and increasing the Mica and/or Revelstoke project's discharge during the summer period. Model output consisted of 50-year monthly flows at various projects and a summary of the effect of project operations by enumerating the frequency with which the NMFS flow objectives are met on a monthly and seasonal basis at Lower Granite, Priest Rapids, McNary, and Bonneville dams. The effect of flow operations on the frequency of storage reservoirs achieving upper (flood control) rule curve on April 10 and refill by June 30 was also summarized. Table 9.7-3 summarizes operational criteria for the hydrosystem regulation study representing foreseeable RPA water management actions in the next 4 to 5 years.

Table 9.7-2. Estimates of minimum adult survival and unaccounted loss based on radio-tracking studies through the FCRPS projects.

	Multi-Year Radio-Tracking Studies		Single Year Reach Studies			Current Condition				RPA Condition	
	1995 BiOp	1998 BiOp	RT 96[1]	RT 97[1]	RT 98[1]	Mean Loss[2]	Minimum Mean Survival[3]	Number of Dams	Per-Project Survival[4]	Minimum Mean Survival[11]	Per-Project Survival
Chinook Salmon											
SR spr/sum chinook	0.209[5]	0.252	0.161	0.158	0.130	0.175	0.825	8	0.976	0.855	0.981
SR fall chinook	0.393				0.187	0.290	0.710	8	0.958	0.740	0.963
UCR spr chinook[6]							0.907	4	0.976	0.922	0.981
LCR spr chinook[6]							0.976	1	0.976	0.981	0.981
LCR fall chinook[7]							0.958	1	0.958	0.963	0.963
Steelhead											
SR steelhead		0.208	0.270	0.204		0.227	0.773	8	0.968	0.803	0.973
UCR steelhead[8]							0.878	4	0.968	0.893	0.973
MCR steelhead[8]							0.878	4	0.968	0.893	0.973
LCR steelhead[8]							0.968	1	0.968	0.973	0.973
SR sockeye salmon	0.154[9]			0.132[10]		0.143	0.857	8	0.981	0.887	0.985

[1] T. Bjornn, pers. comm., November 2000 (data from 1996, 1997 and 1998 radio-tracking studies).
[2] Average of 1995 and 1998 Biological Opinion and radio-tracking studies.
[3] 1 minus mean loss.
[4] Calculated by taking the 8th root of the eight dam minimum mean survival estimates.
[5] Not included in loss/survival estimates (1998 Biological Opinion estimate is an update of the 1995 Biological Opinion estimate).
[6] Calculated from SR spring/summer chinook salmon per-project survival rates.
[7] Calculated from SR fall chinook salmon per-project survival rates.
[8] Calculated from SR steelhead per-project survival rates.
[9] Based on count analyses (1985 to 1994) (1995 Biological Opinion).
[10] Sockeye passage to Wells Dam.
[11] Minimum mean survival for RPA condition is 3% higher than current condition for SR species passing through eight projects, 1.5% higher for species passing through four projects, and 0.5% higher for species passing only through Bonneville Dam.

Table 9.7-3. Summary of criteria for hydrosystem regulation study of RPA actions (Study 00FHS33wo).

Criteria added to base case (00fsh30) operations
1. Additional Grand Coulee draft in low water years (to elev. 1,280 feet if Apr to Aug runoff $\geq$92 Maf and to elev. 1,278 feet if Apr to Aug runoff < 92 Maf).
2. Banks Lake–reduced storage of 5 feet–water returned when most convenient for power and fishery purposes.
3. 2000 Biological Opinion spill levels.
4. VARQ flood control operation at Libby and Hungry Horse dams and USFWS minimum flows (with sliding scale minimum flows at Hungry Horse).
5. Albeni Falls is operated to elevation 2,051 feet from November through April.
6. Fall spawning flows below Bonneville Dam.

9.7.1.3.1 Probability of Achieving NMFS Flow Objectives. Table 9.7-4 provides a summary of the percent of years flows at Lower Granite, Priest Rapids, McNary, and Bonneville dams expected to meet or exceed NMFS flow objectives under the RPA. In comparing the results of Table 9.7-4 to Table 6.2-5, there are little or no changes to monthly flows at Lower Granite Dam. In general, Snake River flows meet or exceed NMFS flow objectives during the spring migration except in the lowest 20 water years. In the summer months, NMFS flow objectives are not achieved in the Snake River except in the highest 10 water years.

At McNary Dam on the Columbia River, there is little or no change in meeting NMFS flow objectives under the RPA compared to current operations in the months of April, May, July, and August. However, there is a 6% increase in achieving the flow objective under the RPA during June, from 50% to 56%. Similarly, the 135 kcfs spring flow objective at Priest Rapids Dam is exceeded in 90% of the years in June, compared to 78% under current operations, a 12% increase. Under the RPA operation, the spring seasonal flow objective is achieved 88% of the time, while the 200 kcfs seasonal flow objective in the summer is exceeded 28% of the time at McNary Dam.

Fall and winter flows at Bonneville Dam for LCR chinook and CR chum salmon spawning and incubation through emergence were also evaluated. A flow objective of at least 125 kcfs was achieved in November in 74% of the years under both the RPA and the proposed action, compared to only 30% if Albeni Falls is held at elevation 2,055 feet for a kokanee spawning evaluation. This flow objective was achieved in 90% of the years in December, a similar frequency as under the proposed action. In January through March, the flow objective was also met with a similar frequency under the RPA as under the proposed action, e.g., 76% to 86% during this period.

Table 9.7-4. Percent of years flows at Lower Granite, Priest Rapids, McNary, and Bonneville dams are expected to meet or exceed specified flow objectives under RPA based on 50-year continuous hydrosystem simulation (1929 through 1978).

Period	Project			
	Lower Granite	Priest Rapids	McNary	Bonneville
January	N/A	N/A	N/A	86
February	N/A	N/A	N/A	78
March	N/A	N/A	N/A	76
April	38	58	48	N/A
May	60	84	64	N/A
June	68	90	56	N/A
July	40	N/A	46	N/A
August	0	N/A	10	N/A
September	N/A	N/A	N/A	10
October	N/A	N/A	N/A	20
November	N/A	N/A	N/A	74
December	N/A	N/A	N/A	90

Source: BPA Hydrosim Run 0Y00.00FSH28.OPER.

9.7.1.3.2 FCRPS Reservoir Effects. Based on the results of BPA's hydrosystem modeling, effects on FCRPS storage reservoir operations under the RPA compared to the proposed action (base case) are summarized below.

Grand Coulee. The 50-year hydrosystem study results indicate the RPA-proposed draft of an additional 2 feet below elevation 1,280 in years when the April-to-August forecast is less than 92 Maf does not affect either 1) refill probability in subsequent years, or 2) the project's ability to achieve elevation 1,283 or above by the end of September (see Section 9.6.1.2.3 for a description of Grand Coulee operations). For example, the modeling results for the RPA operation indicate that FDR Lake refills or reaches its upper rule curve elevation on June 30 in all 50 water years, and the project has a 50-year average elevation of 1,283.5 feet by the end of September. In addition, the 50-year average draft of Grand Coulee reservoir by August 31 is to elevation 1,279.5 feet.

Banks Lake and Columbia Basin Project Pumping. Under the RPA operation, pumping from FDR Lake into Banks Lake is reduced in August by an equivalent volume of the top 5 feet (127 kaf) of storage in Banks Lake in years when this water is needed to meet the McNary Dam flow objective (see Section 9.6.1.2.4 for a description of Banks Lake operations). Additional water is pumped from FDR Lake in the following January-April period to return Banks Lake elevation to its original elevation.

Libby. Libby Reservoir either refills or reaches its upper rule curve elevation by June 30 in 16 years (32%) under the RPA operation as under the proposed action operation (see Section

9.6.1.2.3 for a description of Libby operations). In addition, the 50-year average draft of Libby reservoir at the end of August is elevation 2,442 feet under the RPA operation, as compared to elevation 2,439 feet under the proposed action. At the end of August, the reservoir refills in 2 years under the RPA compared to no years under the proposed action.

Hungry Horse. Hungry Horse Reservoir either refills or reaches its upper rule curve elevation on June 30 in 7 more years, 34 years versus 27 years, in the RPA operation than under the proposed action (see Section 9.6.1.2.3 for a description of Hungry Horse operations). Under both the RPA and the proposed action, the 50-year average draft of Hungry Horse Reservoir at the end of August is 3,543 feet. In addition, the reservoir elevation is between 3,550 feet and 3,560 (full pool) feet on August 31 in 5 years under the RPA, as opposed to 4 years under the proposed action.

Albeni Falls. Except for the USFWS kokanee spawning evaluation during the next 6 years, the RPA operates the Albeni Falls project to elevation 2051 feet during October through April of each year to assist in meeting chum salmon flow needs in the lower Columbia River (see Section 9.6.1.2.3 for a description of Albeni Falls operations).

Dworshak. In the RPA operation as in the proposed action, Dworshak drafts to elevation 1520 feet by the end of August of each year, if needed to support Lower Granite Dam flow objectives and water temperature control (see Section 9.6.1.2.3 for a description of Dworshak operations). In September, the RPA also proposes to draft the project an additional volume of 244 kaf, but no lower than elevation 1,500 feet, to reduce temperature and to meet flow objectives in the lower Snake River as part of an adult fish passage evaluation (see Section 9.6.1.2.6 for a description of Dworshak's September temperature and adult passage evaluation operation). A 50-year hydroregulation study of Dworshak refill probability indicates the September adult study operation, when it is conducted, would have little effect on reservoir refill by the end of June in subsequent years, i.e., there are only two additional refill failures at Dworshak on June 30, and the average of these three refill misses is less than 12 feet from full pool, with two of these misses within 9 feet of full pool. For comparison, the single refill miss under the proposed action was 15 feet from full pool.

9.7.1.4 Water Quality

Gas abatement measures in the RPA will reduce TDG levels and thereby improve water quality and reduce the risk to listed salmonids. Installation of flow deflectors at Chief Joseph Dam will reduce gas entrainment and TDG levels downstream during spill periods at that project. This measure will improve water quality conditions for UCR spring chinook and steelhead adults and juveniles downstream of Chief Joseph Dam. It will also help ensure that spill programs for passage of juvenile UCR spring chinook and steelhead at Wells, Rocky Reach, and Rock Island dams are not affected by elevated gas levels originating at Chief Joseph.

The deflector optimization program at the lower Snake and lower Columbia FCRPS projects will improve water quality and reduce gas entrainment during voluntary juvenile fish passage spill and during involuntary spill periods.

Temperature reduction measures identified in the RPA will help reduce elevated water temperature conditions in the lower Snake River and in fish bypass facilities to improve migration conditions and survival rates of subyearling fall chinook. For example, modifications to water supply intake facilities at Dworshak National Fish Hatchery would eliminate the current operating restrictions on releases of cooler water from Dworshak Reservoir, which would allow for flow volume increases and lower water temperatures in the lower Snake River to improve migratory conditions for summer migrating juvenile fall chinook. Hatchery supply water that is cooler than 54°F (12°C) has been shown to negatively affect the growth of juvenile fish reared at the hatchery. When the required modifications to the hatchery water supply system are completed, it will be possible to augment Snake River flows using Dworshak discharges with temperatures as low as 48°F (9°C), providing a greater cooling effect downstream.

Thermal-related stress is known to contribute to juvenile fish collection mortality at McNary Dam. Hydrothermal computational fluid dynamics (CFD) modeling has the potential to provide quantitative information that would enable the Corps, NMFS, and fishery comanagers to determine the physical effects on water temperature of selected project operation and/or structural modifications at McNary Dam. CFD modeling could help evaluate the potential ability of alternative powerhouse operations to decrease the inflow of elevated summertime water temperatures into gatewells, the juvenile fish collection channel, and raceways.

9.7.1.5 Effects of Predator Control

Improvements in predator control include improvements to the Northern Pikeminnow Management Program and evaluations of avian and marine mammal predation near and above Bonneville Dam. These evaluations may lead to actions that can be implemented to reduce predation. The direct effects of these predator control efforts on juvenile survival are difficult to quantify. However, on the basis of information in the Predation White Paper (NMFS 2000f), NMFS estimates that implementing the RPA measures will reduce FCRPS project pool mortalities of both yearling and subyearling juveniles by an average of approximately 10%. Accordingly, NMFS applied the 10% average reduction in the SIMPAS model.

To illustrate: estimated mortality for yearling spring/summer chinook in John Day Reservoir is approximately 12% (Table 6.2-8). A 10% reduction in mortality would therefore be an absolute change of 1.2%. The White Paper cites an estimate that approximately 7.3% of all juvenile salmonids entering John Day Reservoir annually are lost to northern pikeminnow predation. Table 10 of the White Paper lists model predictions for the expected reduction in the pikeminnow predation rate due to continuation of the predation control program. At John Day, for the years 2000 to 2006, the model estimates that the predation rate will be reduced by approximately 9% annually. Reducing the estimated current pikeminnow predation loss of 7.3% by 9% gives an approximate 0.66% annual reduction in pool mortality due to the predator control program alone. This is about half of the 10% (1.2% absolute) assumed in the RPA analysis.

Other measures in the RPA, such as spill operations and future surface passage facilities, are all expected to further reduce delay at the dam, and therefore exposure to predators. In addition, measures to reduce mortalities due to other piscine and avian predators will also reduce pool mortality rates. Although the pool mortality reduction rate expected from these other measures cannot be quantified at this time, it appears reasonable to expect that these measures, when combined with the reduction expected from the pikeminnow control program, will be sufficient to result in a 10% reduction in pool mortality.

9.7.1.6 Juvenile Transportation Program

9.7.1.6.1 Percentage of Each Species Transported. Under the RPA, the proportion of the SR mixed stock yearling chinook population potentially collected and transported from the three Snake River collector dams is estimated to average about 58%, with a range from 43% to 91% depending on river conditions. For summer migrating SR fall chinook, the proportion transported is lower than that for yearling chinook because of significant mortality that occurs before these fish first reach Lower Granite Dam. The proportion of fall chinook potentially collected and transported is estimated to average about 52%, with a range from 32% to 65% depending on river conditions. Similar estimates for SR steelhead average 60%, with a range from 48% to 90% (Table 9.7-1).

9.7.1.6.2 Survival Benefits to Each Species. Without transportation, the average inriver survival of combined mixed stock SR yearling chinook salmon from Lower Granite Dam to below Bonneville Dam is estimated to be nearly 50%, with a range from 35% to 62% depending on river conditions. With transportation, combined transport and inriver survival to below Bonneville Dam is estimated to be about 76%, with a range from 68% to 90%. For summer migrating SR fall chinook, the proportion of the population surviving to below Bonneville Dam without transportation is estimated to be about 14%, with a range from about 1% to 22%. With transportation, the proportion of the population surviving to below Bonneville Dam is about 51%, with a range from 31% to 64%. Similar estimates for SR steelhead average almost 52% without transportation (range 42% to 58%), and 77% (range 72% to 88%) with transport (Table 9.7-1).

9.7.1.6.3 Effects of Extended Barging Season. This measure addresses the concerns of the Independent Scientific Advisory Board and others in the region regarding potential adverse effects on juvenile fish that are transported by truck as compared to barging. Collected juveniles that migrate early and late in the season have been transported by truck for release below Bonneville Dam. Unlike the summer migrants, which are trucked, all of the early transported migrants are released from the shoreline at selected locations thought to afford the best available release conditions (strong downstream current, deep water in close proximity, no avian predators). Due to safety concerns, trucked fish are routinely released during daylight, a period when avian predators are most active. In contrast, barged fish are released at various midriver locations under more favorable hydraulic conditions where predators have less opportunity to forage.

9.7.1.6.4 Potential Release of Trucked Fish from New Bonneville Juvenile Fish Bypass Outfall. As described above, juvenile fish that are trucked at the beginning of the season are released from the shoreline, where there is increased likelihood of consumption by predators. The new Bonneville juvenile fish bypass outfall was sited to afford bypassed fish a higher survival rate. If the post-construction evaluation of the new outfall does not show any problems, there should be a survival advantage for trucked fish released from that location.

9.7.1.6.5 Transportation from McNary Dam. The potential benefits to listed Upper Columbia species are unknown. Transportation around the remaining three lower Columbia dams would avoid FCRPS-related mortality in that reach and thereby increase their relative survival. On the other hand, collection and transportation from McNary may result in indirect mortality. Evaluations of transport benefits conducted during the 1980s relied on juvenile fish collected by sampling from the juvenile facility. Those fish were most likely a mix of upper Columbia and Snake River fish.

Currently, transport barges from the lower Snake River bypass the McNary Dam juvenile facility and arrive below Bonneville earlier than would otherwise occur. More barged fish are released in daylight instead of after dark, which was the case before transport was suspended.

More juvenile salmon and steelhead that migrate in June would remain inriver to complete their migration if the decision to initiate transportation is based on a daily average riverflow and water temperature criteria. In the past 2 years, collection and transport began when inriver migratory conditions were more favorable to their survival through the lower Columbia River. Because spring migrant transport operations at McNary will continue to be suspended until new studies demonstrate positive benefits, there is no scientific basis for transporting summer migrants passing the project under springlike conditions. Available data do not show a transport benefit for summer migrants transported during the early portion of the migration, and only a slight benefit for the middle segment of the run. Studies in the 1980s were conducted when fish-handling facilities and practices were less favorable than they are now, and the mainstem dams were operated without juvenile fish protection considerations. Future evaluations are desirable to help determine whether summer migrants should be removed from the river under good inriver migratory conditions.

Installation of adult PIT-tag detectors in main fishways at McNary Dam will allow collection of adult return data without any handling. These facilities are essential to conduct transport research at McNary.

9.7.1.6.6 Improvements to Transportation Program. Planning transport operations at the dams so that fish are released from specific areas at specific times to enhance their post-release survival has the potential to reduce estuarine-related predation. At present, fish barges at the uppermost dam are loaded on the day shift in the morning. That schedule determines the barge loading schedule at the downriver projects. No consideration is given to the optimum times that fish would need to be released below Bonneville to ensure the survival rate. Staff resource and safety issues are the primary considerations. Researchers have speculated that survival at the saltwater interface may be higher if transported fish arrive at the estuary concurrent with an outgoing tide. This could reduce delay and potential negative interactions with avian predators (i.e., at Rice Island).

9.7.1.6.7 NMFS' Issuance of Section 10 Permits for Juvenile Transportation Program and Smolt Monitoring Program. The juvenile transportation program is an integral component of the proposed action in this biological opinion. The Corps' existing permit expires on December 31, 2000. Issuance of a new Section 10 permit for the transportation program will be necessary for 2001 and beyond. Effects of bypass and collection of smolts on SR steelhead, UCR steelhead, and SR spring/summer chinook survival are described in Section 6.2.3. Effects of adult fallback through bypass systems are assessed in Section 6.2.4. Effects of transportation, in terms of direct survival to below Bonneville Dam and relative survival to adulthood compared to inriver migrants, are discussed in Section 6.2.8. Biological information regarding all aspects of the transportation program and its effect on listed steelhead and salmon is included in the Transportation White Paper (NMFS 2000i).

The smolt monitoring program is also an integral component of the current action. Issuance of the Section 10 permit for the smolt monitoring program is also necessary for 2001 and beyond (see Appendix H).

9.7.1.7 Summary: Effects of RPA on Juvenile and Adult Survival

The information in Table 9.7-5 summarizes the effects of the RPA on the listed salmon and steelhead juvenile survival rates, estimated using the SIMPAS model, and minimum adult survival rates, estimated from radio-tag study results and listed in Table 9.7-2. Also included in Table 9.7-5, for comparison purposes, are summaries of the effects of the current action on juvenile survival rates, estimated using the SIMPAS model and listed in Appendix D, Tables D-1 through D-3. Minimum adult survival rates, estimated from radio-tag study results, are listed in Table 6.1-1.

Table 9.7-5. Summary of estimated effects of the RPA in the action area.

ESU	Estimated Inriver Juvenile Survival through FCRPS		Estimated Inriver and Transport Juvenile Survival With D through FCRPS		Estimated Adult Survival through FCRPS	
	Current	RPA	Current	RPA	Current	RPA
Chinook Salmon						
SR spr/sum chinook (D = 0.63-0.73)	0.27-0.52	0.35-0.62	0.50-0.64	0.51-0.65	0.83	0.86
SR fall chinook (D = 0.24)	0.005-0.16	0.01-0.22	0.06-0.15	0.08-0.16	0.71	0.74
UCR spring chinook	0.46-0.66	0.55-0.76	N/A	N/A	0.91	0.92
UWR chinook	N/A	N/A	N/A	N/A	N/A	N/A
LCR chinook-spring	0.83-0.91	0.87-0.95	N/A	N/A	0.97	0.98
LCR chinook-fall	0.50-0.80	0.57-0.85	N/A	N/A	0.96	0.96
Steelhead						
SR steelhead (D = 0.52-0.56)	0.32-0.46	0.42-0.58	0.45-0.52	0.46-0.55	0.77	0.80
UCR steelhead	0.57-0.64	0.61-0.74	N/A	N/A	0.88	0.89
MCR steelhead	0.57-0.64	0.61-0.74	N/A	N/A	0.88	0.89
UWR steelhead	N/A	N/A	N/A	N/A	N/A	N/A
LCR steelhead	0.85-0.92	0.86-0.96	N/A	N/A	0.97	0.97
CR chum salmon	0.50-0.80	0.57-0.85	N/A	N/A	0.96	0.96
SR sockeye salmon	N/A	N/A	N/A	N/A	0.86	0.89

9.7.2 Analysis of Effects of Proposed Action on Biological Requirements Over Full Life Cycle

Appendix C describes the median annual population growth rate (lambda) and the risk of absolute extinction at the ESU and, in some cases, the population level. In this section, NMFS looks at the likely effects of the proposed action on the risk of extinction and likelihood of recovery (Section 1.3.1.1 and 6.1.2). Although the jeopardy standard is ultimately a qualitative assessment of whether there is a high likelihood of survival with an adequate potential for recovery, NMFS considers the specific level of improvement needed to achieve particular risk levels as one indication of population status relative to that jeopardy standard (Sections 1.3.1.1 and 6.1.2). These risk levels (≤5% risk of extinction in 24 and 100 years; ≥50% likelihood of meeting interim recovery abundance levels in 48 and 100 years; ≥50% likelihood that population growth rate will be stable or increasing) are referred to subsequently as "survival indicator criteria" or "recovery indicator criteria." This standardized analysis is used to evaluate the importance of the effects described in the preceding section, as likely to occur in the action area in the context of the full life cycle. The data for some of the ESUs considered in this biological opinion are too scarce or are not of adequate quality to permit a quantitative life-cycle analysis of this type. For some of those ESUs, inferences can be drawn from the quantitative results described for the other ESUs.

Details of the quantitative analyses used to evaluate the effects of the proposed action on biological requirements over the full life cycle are described in Section 6.1.2 and Appendix A. Quantitative and qualitative estimates are summarized for several ESUs in the following sections.

9.7.2.1 Snake River Spring/Summer Chinook Salmon

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range, including habitat degradation in many areas due to timber harvest, grazing, and mining practices (loss of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS evaluates quantitatively the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.1.1 Populations Evaluated

NMFS evaluated 43 spawning aggregations of SR spring/summer chinook salmon. Seven of these are the “index stocks” described in the June 27, 2000, draft biological opinion, previous NMFS analyses (McClure et al. 2000b), and PATH reports (Marmorek et al. 1998). The remaining spawning aggregations were the subject of new analyses in McClure et al. (2000c). NMFS has not yet determined which, if any, of the index stocks and additional spawning aggregations represent populations, as defined by McElhany et al. (2000), but all are treated as independent populations because of the statistical assumptions inherent in the analysis.

9.7.2.1.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from the base period lambda necessary to achieve ≥50% likelihood of meeting interim recovery abundance levels (NMFS 1995c) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A. Interim recovery abundance levels have only been defined for three ESUs and, in the SR spring/summer chinook ESU, only for the seven index stocks. Therefore, NMFS estimated the change in lambda necessary to meet an alternative recovery indicator criterion of lambda ≥1.0 (Appendix A) for all other spawning aggregations. Details of each of these estimates are included in Appendix A.

NMFS also investigated the effects of adding preliminary returns in 2000 and an estimate of expected returns in 2001 (based on jack abundance) to the time-series used to estimate lambda in each of the calculations described above. Estimates are included in McClure (2000b). These preliminary returns were included in the lowest estimates of necessary survival changes.

9.7.2.1.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from 1980 to 1999 will continue indefinitely. However, in Section 6.3.1.3, NMFS estimates that current survival represents a 24%-to-32% improvement over the average survival rate influencing base period adult returns. The range represents two methods of estimating survival change. One relies entirely on PATH results, and the other relies on a combination of PATH and SIMPAS model estimates (Section 6.3.1.3). Implementing the hydrosystem component of the RPA will proportionally increase adult survival beyond the current level by an additional 3.7%, based on information in Table 9.7-5. The hydrosystem component of the RPA will also increase juvenile survival to below Bonneville Dam, including differential post-Bonneville survival of transported fish (D) of 63% to 73%, by approximately 1% (Table 9.7-5). The product of the proportional survival improvements associated with the current conditions and the RPA results in an expected survival improvement of 30% to 38% (1.30 to 1.38 times the average base period survival rate), as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period condition and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates is included in this quantitative analysis. In Section 9.7.2.1.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.1.4 Additional Necessary Survival Changes

Table 9.7-6 shows the effect of the 30% to 38% survival rate increase expected from the hydrosystem component of the RPA on the future median annual population growth rates for 43 SR spring/summer chinook spawning aggregations. In some cases (e.g., Marsh Creek), the resulting population growth rate is expected to change from a declining trend (lambda <1.0) to a stable or increasing trend. In spite of the expected improvement in population growth rate, at least 22, and possibly as many as 25, of the 43 spawning aggregations require additional survival improvements to meet the survival and recovery indicator criteria. Table 9.7-6 displays the additional improvements in survival that would be necessary, beyond the 30% to 38% improvement associated with the RPA, to reduce the 100-year extinction risk to 5% and either increase the likelihood of recovery in 48 years to 50% or increase the likelihood of achieving a stable or increasing population growth rate to 50%. These indicator criteria were presented because, if they are achieved, all the survival and recovery indicator criteria will be achieved.

Values in Table 9.7-6 less than or equal to 1.0 indicate that no further survival improvements are necessary to meet the survival and recovery indicator criteria. Values greater than 1.0 represent the multiplier by which survival would have to improve to achieve these criteria. For example, the survival change necessary to reduce the risk of extinction in 100 years to 5% (columns 8 and 9 of Table 9.7-6) is 0.85 to 1.05 for the Sulphur Creek index stock. This means that the RPA, combined with expected survival in other life stages (see Section 9.7.2.1.6, below), is sufficient to reduce the 100-year extinction risk to 5% or less under the highest estimate of the expected survival change and the lowest estimate of the needed improvement. On the other hand, under the lowest estimate of the expected survival change and the highest estimate of the needed survival change, an additional 5% survival improvement (1.05 times expected survival rate) is necessary. This means that an additional 5% increase in egg-to-adult survival, or any component life-stage-specific survival rate, would be necessary to achieve no more than a 5% risk of extinction in 100 years for this index stock under the most pessimistic assumptions evaluated by NMFS.

Table 9.7-6. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing RPA.

Spawning Aggregation	1980-Current Lambda Low[1]	1980-Current Lambda High[2]	Expected Survival Change Low[3]	Expected Survival Change High[4]	Expected Lambda Low[5]	Expected Lambda High[6]	*Additional Change In Survival Needed to Achieve:* 5% Extinction Risk In 100 Years Low[7]	5% Extinction Risk In 100 Years High[8]	50% Recovery In 48 Years or Lambda = 1.0 Low[7]	50% Recovery In 48 Years or Lambda = 1.0 High[8]
ESU Aggregate	0.82	0.91	1.30	1.38	0.86	0.98	1.46	1.56	1.12	1.89
Index Stocks:										
Bear Valley/Elk Creeks	1.02	1.03	1.30	1.38	1.07	1.10	0.72	0.77	0.79	0.89
Imnaha River	0.88	0.92	1.30	1.38	0.93	0.99	0.84	1.16	1.26	1.66
Johnson Creek	1.01	1.03	1.30	1.38	1.07	1.11	0.72	0.77	0.70	0.83
Marsh Creek	0.99	1.00	1.30	1.38	1.04	1.07	0.74	0.89	0.98	1.12
Minam River	0.93	1.02	1.30	1.38	0.99	1.10	0.72	1.13	0.84	1.28
Poverty Flats	0.99	1.02	1.30	1.38	1.05	1.11	0.72	0.77	0.73	0.90
Sulphur Creek	1.04	1.05	1.30	1.38	1.10	1.13	0.85	1.05	0.78	0.87
Additional Aggregations:										
Alturas Lake Ck	0.75	0.75	1.30	1.38	0.79	0.80	N/A	N/A	2.68	2.86
American R	0.91	0.91	1.30	1.38	0.96	0.98	N/A	N/A	1.11	1.19
Big Sheep Ck	0.85	0.88	1.30	1.38	0.90	0.92	N/A	N/A	1.29	1.58
Beaver Cr	0.95	0.95	1.30	1.38	1.01	1.02	N/A	N/A	0.90	0.96
Bushy Fork	0.98	0.98	1.30	1.38	1.04	1.05	N/A	N/A	0.79	0.84
Camas Cr	0.92	0.92	1.30	1.38	0.98	0.99	N/A	N/A	1.04	1.11
Cape Horn Cr	1.05	1.05	1.30	1.38	1.12	1.13	N/A	N/A	0.58	0.61
Catherine Ck	0.78	0.85	1.30	1.38	0.83	0.84	N/A	N/A	1.50	2.31
Catherine Ck N Fk	0.92	0.92	1.30	1.38	0.98	0.99	N/A	N/A	1.04	1.12
Catherine Ck S Fk	0.80	0.80	1.30	1.38	0.84	0.86	N/A	N/A	2.01	2.14
Crooked Fork	1.00	1.00	1.30	1.38	1.06	1.07	N/A	N/A	0.73	0.78
Grande Ronde R	0.77	0.84	1.30	1.38	0.82	0.83	N/A	N/A	1.58	2.42
Knapp Cr	0.89	0.89	1.30	1.38	0.94	0.96	N/A	N/A	1.22	1.30
Lake Cr	1.06	1.06	1.30	1.38	1.12	1.14	N/A	N/A	0.56	0.60
Lemhi R	0.98	0.98	1.30	1.38	1.03	1.05	N/A	N/A	0.81	0.86
Lookingglass Ck	0.72	0.79	1.30	1.38	0.77	0.78	N/A	N/A	2.02	3.25
Loon Ck	1.00	1.00	1.30	1.38	1.06	1.08	N/A	N/A	0.71	0.76
Lostine Ck	0.87	0.90	1.30	1.38	0.92	0.94	N/A	N/A	1.15	1.44
Lower Salmon R	0.92	0.92	1.30	1.38	0.97	0.99	N/A	N/A	1.07	1.14
Lower Valley Ck	0.92	0.92	1.30	1.38	0.98	0.99	N/A	N/A	1.03	1.10
Moose Ck	0.94	0.94	1.30	1.38	1.00	1.02	N/A	N/A	0.93	1.00
Newsome Ck	1.03	1.03	1.30	1.38	1.09	1.10	N/A	N/A	0.64	0.68
Red R	0.91	0.91	1.30	1.38	0.96	0.98	N/A	N/A	1.10	1.18
Salmon R E Fk	0.94	0.94	1.30	1.38	1.00	1.01	N/A	N/A	0.96	1.02
Salmon R S Fk	1.06	1.06	1.30	1.38	1.12	1.14	N/A	N/A	0.56	0.60
Secesh R	0.98	0.98	1.30	1.38	1.03	1.05	N/A	N/A	0.80	0.86
Selway R	0.91	0.91	1.30	1.38	0.97	0.98	N/A	N/A	1.08	1.15
Sheep Cr	0.80	0.80	1.30	1.38	0.85	0.86	N/A	N/A	1.97	2.10
Upper Big Ck	0.97	0.97	1.30	1.38	1.03	1.04	N/A	N/A	0.87	0.89
Upper Salmon R	0.90	0.90	1.30	1.38	0.96	0.97	N/A	N/A	1.13	1.21
Upper Valley Ck	1.03	1.03	1.30	1.38	1.09	1.11	N/A	N/A	0.63	0.67
Wallowa Ck	0.86	0.86	1.30	1.38	0.91	0.92	N/A	N/A	1.42	1.51
Wenaha R	0.84	0.90	1.30	1.38	0.89	0.91	N/A	N/A	1.14	1.66
Whitecap Ck	0.90	0.90	1.30	1.38	0.96	0.97	N/A	N/A	1.14	1.22
Yankee Fork	0.88	0.88	1.30	1.38	0.94	0.95	N/A	N/A	1.26	1.35
Yankee West Fk	0.99	0.99	1.30	1.38	1.05	1.06	N/A	N/A	0.76	0.81

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
[3] Low represents estimation of juvenile survival improvement based on a comparison of PATH retrospective and prospective (A2) results.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS results.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for index stocks) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

Three of the seven index stocks require no additional survival changes beyond those expected under the RPA to meet the survival and recovery indicator criteria. The other four index stocks require additional survival improvements ranging from 0% to 66%. For the additional spawning aggregations, data were insufficient for estimating extinction risk, and no interim recovery levels have yet been determined. For the spawning aggregations, the necessary survival change is that which will result in lambda of 1.0. Under all assumptions, 21 of the 36 spawning aggregations require additional survival changes, ranging from 3% to 239%. One additional spawning aggregation needs no additional survival change under the best-case assumptions that NMFS evaluated, but needs a 2% survival change under the worst-case assumptions. The remaining 14 spawning aggregations require no additional survival improvements under any of the assumptions evaluated.

These results are similar to those of PATH (Marmorek et al. 1998, Peters and Marmorek 2000), with respect to the need for additional survival improvements after the hydrosystem component of the RPA is implemented, in order to meet approximations of the survival and recovery indicator metrics. However, the magnitude of the necessary changes differs between the two approaches and among different PATH reports. Section 6.3.1.4 compares the NMFS and PATH analyses of modeling scenarios approximating the proposed action. Implementation of the hydrosystem RPA does not fundamentally change the discussion in that section. Briefly, PATH (Peters and Marmorek 2000) and NMFS generally estimate a similar range of extinction risk, and PATH (Marmorek et al. 1998) and NMFS results suggest that a relatively small survival improvement is necessary to meet the recovery indicator metric for the sixth-worst stock. However, the PATH experimental management analysis (Peters and Marmorek 2000) suggests that well over a 100% improvement in survival is needed for the worst stock to meet the recovery indicator metric.

9.7.2.1.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the RPA's ability to achieve survival and recovery indicator criteria. The substantial comments primarily questioned the estimates of hydrosystem survival associated with the RPA (addressed in Section 9.7.1), the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed in Section 6.3.1.3 in one new and one modified method of estimating the expected change), the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% of that of wild-origin spawners (addressed in Section 6.3.1.5), and the analytical assumption that all survival changes are achieved instantaneously. This last point is addressed below.

The simple analytical approach used in this biological opinion assumes that all survival changes are instantaneous (McClure et al. 2000c). To the extent that improvements are implemented gradually, the analysis underestimates the survival change that will ultimately be required. The magnitude of the additional change depends on the stock under consideration and the length of the delay. To demonstrate the effect of this assumption, NMFS evaluated a 10-year delay in implementing the hydrosystem component of the RPA and of achieving any survival improvements in other life stages (Appendix A). The analysis also assumed that there has been no change from average base period survival as a result of current hydrosystem operations (which NMFS estimates as a 24%-to-32% improvement in Section 6). Further, the survival changes associated with current operations are assumed not to occur for 10 years. NMFS applied this extremely pessimistic assumption to the Imnaha River stock, which is the SR spring/summer chinook stock requiring the greatest survival improvement. Given these assumptions, a 58% to 95% survival improvement would be necessary at the end of 10 years to meet the recovery indicator criteria. In contrast, the estimate from the present analysis is a survival improvement of 26% to 66%. NMFS considers that effect qualitatively in making a jeopardy determination.

This analysis also contains assumptions that may make the results overly pessimistic. Three of these are the analytical assumptions that all spawning aggregates behave as independent populations; that all supplementation programs cease immediately; and that background survival will continue as it has since 1980. These assumptions are discussed in detail in Section 6.3.5.

9.7.2.1.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-6 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for SR spring/summer chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above Lower Granite Dam. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. The RPA also provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.2 Snake River Fall Chinook Salmon

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Specifically, almost all of the historical spawning habitat in the Snake River basin is blocked by the Hells Canyon Complex. Other irrigation and hydroelectric projects block access to habitat in tributaries to the Columbia River below Hells Canyon. Habitat quality is degraded by agricultural water withdrawals, grazing, vegetation management, and forestry and mining practices (lack of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS quantitatively evaluates the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.2.1 Populations Evaluated

NMFS analyzed the single aggregate Snake River fall chinook population. The analysis was based on Lower Granite Dam counts, so it does not include spawning areas in the Tucannon River and in the mainstem below some Corps dams.

9.7.2.2.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the aggregate population interim recovery abundance level (based on NMFS 1995c; specifics in Appendix A) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A.

9.7.2.2.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. However, in Section 6.3.2.3, NMFS estimates that current survival represents a 31%-to-63% improvement over the average survival rate influencing base period adult returns. The range represents four methods of estimating the survival change. One estimate of the juvenile passage survival change relies entirely on PATH results, whereas the other relies on a combination of PATH and SIMPAS model estimates (Section 6.3.2.3). One estimate of the change in harvest rate relies on PATH estimates, whereas the other relies on a PSC model estimate. The lowest survival improvement results when both juvenile survival and harvest are estimated using only PATH results. The highest survival represents the combination of PATH and SIMPAS juvenile modeling and the PSC harvest modeling results.

Implementing the hydrosystem component of the RPA will proportionally increase adult survival beyond the current level by an additional 4.2%, based on information in Table 9.7-5. The hydrosystem component of the RPA will also increase juvenile survival to below Bonneville Dam, including an assumed differential post-Bonneville survival of transported fish (D) of 24% (Section 6.2.3.3) by approximately 9% (Table 9.7-5). The product of the proportional survival improvements associated with the current conditions and the RPA results in an expected survival improvement of 49% to 86.0% (1.49 to 1.86 times the average base period survival rate), as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.2.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.2.4 Additional Necessary Survival Changes

Table 9.7-7 shows the effect of the 49%-to-86% increase in survival rate expected from the RPA on the future median annual population growth rates for the aggregate SR fall chinook population. The resulting population growth rate is expected to change from a declining trend (lambda <1.0) to a stable or increasing trend (lambda = 1.07) under the highest estimate of survival change. However, under the lowest estimate of improved survival, the population growth rate is still expected to decline. No additional survival improvements are necessary to meet the survival indicator criteria under any of the assumptions considered in this analysis. Nor are any additional survival improvements required to meet the recovery indicator criteria when the highest expected change in survival is coupled with the lowest estimate of the necessary survival improvement. However, an additional 44% survival change is required when the low estimate of the expected survival change is coupled with the highest estimate of the needed survival improvement.

The results of the NMFS Snake River fall chinook analysis for the hydrosystem component of the RPA are generally consistent with the PATH assessments of a similar action. Both assessments indicate that no additional survival changes are needed to meet alternative survival indicator criteria, given similar assumptions regarding annual climate/environmental variability, harvest rates, and differential mortality for transported smolts. However, both assessments

Table 9.7-7. Snake River fall chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
Aggregate SR fall chinook	0.87	0.92	1.49	1.86	0.96	1.07	0.66	0.94	0.93	1.44

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents estimation of juvenile survival improvement based on PATH retrospective and prospective (A2) results and change in harvest rate based on PATH.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS and harvest rate change based on PSC modeling.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

indicate that additional survival improvements would be required to meet the 48-year recovery indicator criterion under the full range of assumptions considered in each analysis.

PATH evaluated an action (A2) that incorporated most of the elements of the hydrosystem component of the RPA with respect to SR fall chinook (Peters and Marmorek 2000). The action A2 incorporated the changes in hydropower operations called for in the 1995 FCRPS Biological Opinion. While it incorporates similar juvenile survival assumptions, the PATH analysis does not include the adult survival improvement anticipated from the RPA. PATH evaluated actions under a range of assumptions regarding post-Bonneville Dam differential delayed mortality of transported fish relative to nontransported fish (expressed as a differential survival factor D). The ability of action A2 to meet PATH survival and recovery criteria depended on the assumption regarding D. If D is relatively high or if it had improved substantially over base values, PATH projected that A2 would readily exceed survival and recovery criteria used in the assessments. Under the assumption that D has remained at approximately 20%, approximating the level used in the current NMFS analysis (see Section 6.2.3.3), action A2 was projected to meet survival criteria but to fall short of recovery targets. Specifically, the PATH analysis projected the mean likelihood of reaching recovery goals in 48 years as 34%, 16 percentage points below the 50% likelihood associated with the recovery indicator criterion.

9.7.2.2.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the RPA's ability to achieve survival and recovery indicator criteria. Most comments were not specific to SR fall chinook salmon, but many of the points raised for SR spring/summer chinook salmon may also apply to SR fall chinook salmon. Substantial comments primarily questioned 1) the estimates of hydrosystem survival associated with the RPA (addressed in Section 9.7.1), 2) the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed in Section 6.3.2.3 through introduction of one new and one modified method of estimating the expected change), 3) the method of estimating the change in harvest rate (addressed in Section 6.3.2.3 through introduction of one new and one modified method), 4) the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% that of wild-origin spawners (addressed in Section 6.3.2.3), and 5) the analytical assumption that all survival changes are achieved instantaneously. This last point is addressed below.

The simple analytical approach used in this biological opinion assumes that all survival changes are instantaneous (McClure et al. 2000c). To the extent that improvements are implemented gradually, the analysis underestimates the survival change that will ultimately be required. The magnitude of the additional change depends on the stock under consideration and the length of the delay. To demonstrate the effect of this assumption, NMFS evaluated a 10-year delay in implementing the hydrosystem component of the RPA and of achieving any survival improvements in other life stages (Appendix A). The analysis also assumed that there has been no change from average base period SR fall chinook survival as a result of current hydrosystem operations (which NMFS estimates as a 33%-to-64% improvement in Section 6). Further, the survival changes associated with current operations are assumed not to occur for 10 years. Given these assumptions, a 16%-to-69% survival improvement would be necessary at the end of 10 years to meet the recovery indicator criteria. In contrast, the estimate from the present analysis is a 0%-to-44% survival improvement. NMFS considers this effect qualitatively in making a jeopardy determination.

This analysis also contains assumptions that may make the results overly pessimistic. Two of these are the analytical assumptions that all supplementation programs cease immediately and that background survival will continue as it has since 1980. These assumptions are discussed in Section 6.3.2.5.

9.7.2.2.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-7 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for SR fall chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above Lower Granite Dam. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.3 Upper Columbia River Spring Chinook Salmon

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Chief Joseph Dam and Grand Coulee Dam prevent access to historical spawning grounds farther upstream. Local problems relate to irrigation diversions and hydroelectric development, as well as degraded riparian and instream habitat from urbanization and livestock grazing along riparian corridors.

In this section, NMFS quantitatively evaluates action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.3.1 Populations Evaluated

NMFS analyzed the three populations identified by Ford et al. (1999) as components of this ESU: the Wenatchee River population, the Methow River population, and the Entiat River population. Ford et al. (1999) identified interim recovery goals for each population and included the criterion that all three must meet these goals for delisting.

9.7.2.3.2 Necessary Survival Change

McClure et al. (2000b,c) and Cooney (2000) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. Cooney (2000) and NMFS (Appendix A) also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the three population interim recovery abundance levels (Ford et al. 1999) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A. The CRI analytical approach (McClure et al. 2000b) and the QAR analytical approach (Cooney 2000) produce different estimates of needed survival changes for these populations. NMFS considers both approaches to have advantages and disadvantages and uses results from both to define a range of necessary survival change.

NMFS also investigated the effects of adding 1999-to-2000 preliminary and 2001 projected returns to the time-series used to estimate lambda in each of the calculations described above. The 2001 projections are based on recent jack counts. Estimates are included in McClure et al. (2000b) and Cooney (2000). These preliminary returns were included in the preliminary estimates are included in the lowest estimates of necessary survival changes.

9.7.2.3.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from 1980 to 1998 will continue indefinitely. However, the Basinwide Recovery Strategy identifies implementation of the Mid-Columbia HCP at five PUD projects as a probable element of recovery planning that is, therefore, included in the analysis, consistent with step 4 of the jeopardy analysis framework described in Section 1.3. The Basinwide Recovery Strategy estimates that this action will be implemented within 2 to 5 years. Cooney (2000, Table 20) estimates that implementing the HCP will improve survival 28% for the Wenatchee population, 40% for the Entiat population, and 49% for the Methow population.

In addition, in Section 6.3.3.3, NMFS estimates that current FCRPS hydrosystem survival, combined with implementation of the Mid-Columbia HCP, represents a 7%-to-41% improvement over the average survival rate influencing base period adult returns. The range represents different effects of the HCP on each population and a range of estimates of the historical differential post-Bonneville survival (D = 0.8 to D = 1.0) in years when fish were transported from McNary Dam. Implementing the hydrosystem component of the RPA will proportionally increase adult survival through the FCRPS projects beyond the current level by an additional 1.5%, based on information in Table 9.7-5. The hydrosystem component of the RPA is also expected to proportionally increase juvenile survival to below Bonneville Dam by 15.5% (Table 9.7-5; Appendix A). The product of the proportional survival improvements associated with the current conditions, implementation of the HCP, and implementation of the hydrosystem RPA results in an expected survival improvement of 25% to 65% (1.25 to 1.65 times the average base period survival rate), as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival (other than those associated with the HCP; Cooney 2000), estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.3.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.3.4 Additional Necessary Survival Changes

Table 9.7-8 shows the effect of the 25%-to-65% survival rate increase expected from the proposed action on the future median annual population growth rates for the three UCR spring chinook populations. These effects vary according to whether the QAR analytical approach (Cooney 2000) or the CRI analytical approach (McClure et al. 2000c) is used to estimate the current population growth rate and the necessary change. The CRI approach indicates that the population growth rate will continue to be negative for all three populations after HCP implementation and continuation of the proposed action, except for the Methow River population under the highest expectation (lambda = 1.01). Additional survival improvements ranging from 32% to 178% (1.32 to 2.78 times the average base period survival rate) will be necessary to meet the recovery indicator criteria. The QAR approach yields slightly more optimistic results, indicating that at least one, and possibly all three populations (under most optimistic assumptions), will have positive growth rates after HCP implementation and continuation of the proposed action. However, additional survival improvements ranging from 24% to 116% (1.24 to 2.16 times the average base period survival rate) will be necessary to meet the recovery indicator criteria.

9.7.2.3.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, UCR spring chinook salmon. However, three comments of particular relevance were that NMFS should not assume that the Mid-Columbia HCP will be implemented and achieve its survival goals within the time described in the Basinwide Recovery Strategy; that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously; and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners. As described in Section 6.3.3.5, NMFS considers the full range of hatchery spawner effectiveness in this biological opinion.

Table 9.7-8. Upper Columbia River spring chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate - CRI	0.84	0.85	1.36	1.54	0.90	0.94	1.20	1.41	1.32	1.58
Methow River - QAR	0.90	0.90	1.46	1.65	0.98	1.14	0.80	0.91	1.24	1.41
Entiat River - QAR	0.89	0.89	1.37	1.55	0.96	0.99	1.01	1.15	1.36	1.55
Wenatchee R. - QAR	0.88	0.92	1.25	1.42	0.93	1.09	0.99	1.40	1.51	2.16
Methow River - CRI	0.85	0.89	1.46	1.65	0.93	1.01	1.29	1.66	1.32	1.90
Entiat River - CRI	0.81	0.89	1.37	1.55	0.88	0.99	0.98	1.66	1.32	2.19
Wenatchee R. - CRI	0.80	0.85	1.25	1.42	0.84	0.92	1.22	1.83	1.84	2.78

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically and inclusion of preliminary and projected returns through 2001 for CRI estimates.
[3] Low represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for all except Methow QAR and Entiat QAR) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

The first comment applies to implementation of the proposed Mid-Columbia HCP. CRITFC believes that anticipated HCP survival rates will not be achieved at all five PUD dams for at least 10 years because long-term gas-abatement projects are needed to achieve the necessary spill levels. NMFS agrees that there is some uncertainty about the exact schedule for achieving all survival improvements anticipated in the HCP, but the proposed HCP for the Chelan and Douglas PUDs and the draft EIS anticipate that the survival improvements will be achieved by the end of Phase I (2003). If this does not occur, it is reasonable to anticipate additional changes under the terms of the proposed HCP.

Regardless of the exact implementation schedule, the analysis described above does assume that HCP and hydrosystem RPA survival improvements are achieved immediately, which is not the case. NMFS conducted a sensitivity analysis on the effect of a 10-year delay in implementing *any* survival improvements over the base period average survival rate (Section 6.3.3.5; Appendix C). Under this worst-case scenario, the CRI estimate of necessary survival change for the Wenatchee population increases from the estimate in Table 9.7-8 (additional 84% to 178% change) to a 265% to 368% change (Appendix A). This extreme scenario is unlikely, since some improvements associated with the HCP have already been achieved, but NMFS considers the implications of delayed implementation qualitatively in reaching jeopardy conclusions for this ESU.

This analysis also contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980. These assumptions are discussed in Section 6.3.3.5.

9.7.2.3.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management, other than effects anticipated in the HCP. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-8 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for UCR spring chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above Lower Granite Dam. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. The RPA also provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.4 Upper Willamette River Chinook Salmon

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UWR chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the loss of habitat due to inundation or blockages resulting from the construction of numerous tributary hydroelectric and irrigation facilities, and habitat degradation due to timber harvest, development (agricultural, municipal, and industrial), dam development, and river channelization and dredging. Many of these activities result in poor water quality, high sediment loads, altered thermal regimes, and a large reduction in available spawning and rearing habitat.

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.4.1 Populations Evaluated

NMFS quantitatively evaluated one spawning aggregation, the McKenzie River above Leaburg Dam. Adequate information was not available for similar analyses for additional spawning aggregations. NMFS has not yet determined which, if any, of the UWR chinook spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the McKenzie River aggregation as an independent population satisfies the statistical assumptions inherent in the analysis.

9.7.2.4.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the McKenzie River spawning aggregation. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for this spawning aggregation. Details of these estimates are provided in Appendix A.

9.7.2.4.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for UWR chinook salmon, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. NMFS cannot identify any significant changes in survival rates under the RPA compared with those that influenced the base period adult returns, because survival changes due to implementing the proposed action can be quantified only for species that migrate past mainstem dams (which excludes UWR chinook salmon). NMFS was also unable to quantify potential changes in egg-to-smolt survival, estuary survival, or adult survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 9.7.2.4.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.4.4 Additional Necessary Survival Changes

Table 9.7-9 shows that the RPA is not expected to increase the population survival rate; a negative median annual population growth rate is expected to continue for the UWR chinook spawning aggregation in the McKenzie River above Leaburg Dam. An additional survival improvement of from 9% to 65% (1.09 to 1.65 times the average base period survival rate) is needed to meet the extinction indicator criteria.

Table 9.7-9. Upper Willamette River chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
McKenzie River above Leaburg Dam	0.90	0.99	1.00	1.00	0.90	0.99	1.09	1.65	1.05	1.59

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.4.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations noted that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, UWR chinook salmon. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980. These points are addressed in Section 6.3.1.5.

9.7.2.4.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam, or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-9 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for UWR chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above Willamette Falls). The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive actions within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.5 Lower Columbia River Chinook Salmon

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of LCR chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the impacts of timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development; dams on the Cowlitz, Lewis, (Big) White Salmon, Clackamas, Sandy, and Hood rivers, which block fish passage to historical spawning areas; residual effects of mudflows from the Mt. St. Helens eruption (1980), which significantly disrupted and degraded habitat in the South Fork Toutle and Green rivers – as did post-eruption dredging, diking, and bank protection works in the Cowlitz River (below its confluence with the Toutle River); hatchery programs, beginning in the 1870s, which released billions of fish, homogenizing stocks between subbasins and introducing others from outside the ESU such that most of the fall-run chinook salmon spawning today in the Lower Columbia River ESU are first-generation hatchery strays; and an average total exploitation rate on fall-run stocks from this ESU of 65% for the base period brood years (approximately 45% in the ocean and 20% in freshwater).

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.5.1 Populations Evaluated

NMFS quantitatively evaluated 20 spawning aggregations below Bonneville Dam. Adequate information was not available for similar analyses for spawning aggregations above Bonneville Dam. NMFS has not yet determined which, if any, of the LCR chinook salmon spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the 20 aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.5.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the 20 spawning aggregations of LCR chinook salmon. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

9.7.2.5.3 Expected Survival Change

NMFS' calculation of the needed survival change (improvement in population growth rate) for the 20 spawning aggregations of LCR chinook salmon referenced above assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses passes this project. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 9.7.2.5.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.5.4 Additional Necessary Survival Changes

Table 9.7-10 shows that the RPA is not expected to increase the survival rate of these 20 LCR chinook salmon spawning aggregations, all located below Bonneville Dam; negative median annual population growth rates are expected to continue. Survival improvements needed to meet the survival and recovery indicator criteria range from 3% to 732% (1.03 to 8.32 times the average base period survival rates). For the Lewis and Clark spawning aggregation, improvements of 934% to 1,493% (10.34 to 15.93 times the average base period survival rates) are needed.

Table 9.7-10. Lower Columbia River chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
Aggregations Above Bonneville Dam:										
(insufficient information for analysis)										
Aggregations Below Bonneville Dam:										
Bear Creek	0.73	0.82	1.00	1.00	0.73	0.82	2.14	3.13	1.89	2.83
Big Creek	0.84	0.93	1.00	1.00	0.84	0.93	1.10	1.62	1.31	1.97
Clatskanie	0.80	0.89	1.00	1.00	0.80	0.89	2.93	4.12	1.55	2.32
Cowlitz Tule	0.82	0.92	1.00	1.00	0.82	0.92			1.33	1.99
Elochoman	0.88	0.99	1.00	1.00	0.88	0.99			1.04	1.56
Germany	0.83	0.93	1.00	1.00	0.83	0.93			1.30	1.95
Gnat	0.84	0.94	1.00	1.00	0.84	0.94	2.07	2.95	1.27	1.91
Grays Tule	0.76	0.85	1.00	1.00	0.76	0.85			1.76	2.64
Kalama Spring	0.76	0.85	1.00	1.00	0.76	0.85			1.87	2.80
Kalama	0.89	0.99	1.00	1.00	0.89	0.99			1.06	1.58
Klaskanine	0.80	0.89	1.00	1.00	0.80	0.89	2.30	3.27	1.54	2.30
Lewis R Bright	0.97	0.99	1.00	1.00	0.97	0.99			1.05	1.11
Lewis Spring	0.81	0.91	1.00	1.00	0.81	0.91			1.46	2.20
Lewis, E Fk Tule	0.99	0.99	1.00	1.00	0.99	0.99			1.03	1.03
Lewis and Clark	0.49	0.54	1.00	1.00	0.49	0.54			10.34	15.93
Mill Fall	0.72	0.81	1.00	1.00	0.72	0.81	2.44	3.58	2.19	3.29
Plympton	0.86	0.95	1.00	1.00	0.86	0.95	1.18	1.74	1.21	1.82
Sandy Late	0.98	0.98	1.00	1.00	0.98	0.98	1.00	1.00	1.07	1.09
Skamokawa	0.74	0.82	1.00	1.00	0.74	0.82			2.05	3.08
Youngs	0.84	0.94	1.00	1.00	0.84	0.94	6.73	8.32	1.25	1.88

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.5.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, LCR chinook salmon. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980. These points are addressed in Section 6.3.1.5.

9.7.2.5.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-10 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for LCR chinook salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival and estuary survival. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive actions within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.6 Snake River Steelhead

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Hydrosystem projects create substantial habitat blockages for this ESU. The major ones are the Hells Canyon Complex on the mainstem Snake River and Dworshak Dam on the North Fork of the Clearwater River. Minor blockages are common throughout the region. Steelhead spawning areas have been degraded by overgrazing, as well as by historical gold dredging and sedimentation due to poor land management. Hatchery fish are widespread and stray to spawn naturally throughout the region. In the 1990s, an average of 86% of adult steelhead passing Lower Granite Dam were of hatchery origin. However, hatchery contribution to naturally spawning populations varies across the region. Some stocks are dominated by hatchery fish, whereas others are composed of all wild fish.

In this section, NMFS quantitatively evaluates the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.6.1 Populations Evaluated

NMFS evaluated A-run and B-run aggregate groups of SR steelhead (McClure et al. 2000b,c). These analyses are based on Lower Granite Dam counts, with the two groups distinguished by date and/or size. Once past Lower Granite Dam, SR steelhead spawn in tributaries throughout the lower Snake River basin, and it is likely that there are multiple populations within these aggregates. However, populations have not yet been defined according to criteria in McElhany et al. (2000) and spawner data from tributaries are not available. The Idaho Department of Fish and Game, in comments on the July 27, 2000, Draft Biological Opinion, suggested that NMFS should assign lower abundance levels to each aggregate group, to simulate the greater risk of extinction faced by smaller populations that probably exist in the basin. In response, NMFS evaluated the sensitivity of necessary survival changes to steelhead pseudopopulations, defined as 10% of the abundance of the A-run aggregate and 33% of the B-run aggregate abundance (McClure et al. 2000b; Appendix A). These approximations were based on information on spawning distribution contained in Busby et al. (1996) and the 1990 NWPPC subbasin plans (Tucannon River, Salmon River, Grande Ronde River, and Clearwater River plans). Those documents identify the major summer steelhead spawning areas with respect to each ESU. B-run steelhead are believed to return mainly to three general areas (Middle Fork Salmon River, Upper Salmon River, and South Fork Salmon River). Summer steelhead returns classified as A-run appear to be distributed among a wider array of spawning areas throughout the Snake River region.

9.7.2.6.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period lambda necessary to achieve $\geq$50% likelihood of meeting the lambda $\geq$1.0 (Appendix A) recovery indicator criterion. Details of these estimates are included in Appendix A.

9.7.2.6.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns in the base period will continue indefinitely. However, in Section 6.3.6.3, NMFS estimates that current survival of the A-run aggregate represents a 33%-to-42% improvement over the average survival rate influencing base period adult returns. NMFS estimated that B-run survival has improved 44% to 54%. These estimates represent a combination of reduced harvest rates, which differ for the two aggregates, and an expectation that juvenile passage survival has changed proportionate to that of SR spring/summer chinook salmon for both stocks. Rationale and methods are described in Section 6.3.6.3 and Appendix A.

Implementing the hydrosystem component of the RPA will proportionally increase adult survival beyond the current level by an additional 3.9%, based on information in Table 9.7-5. The hydrosystem component of the RPA will also increase juvenile survival to below Bonneville Dam, including differential post-Bonneville survival of transported fish (D) of 52% to 58%, by 4.4% (Table 9.7-5). The product of the proportional survival improvements associated with the current conditions, including harvest reductions, and the hydrosystem RPA actions results in an expected survival improvement of 44% to 54% (1.44 to 1.54 times the average base period survival rate) for A-run SR steelhead and 56% to 67% (1.56 to 1.67 times the average base period survival rate) for B-run SR steelhead, as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period condition and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.6.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.6.4 Additional Necessary Survival Changes

Table 9.7-11 shows the effect of the 44% to 54% A-run survival rate increase and the 56% to 67% B-run survival increase expected from the hydrosystem component of the RPA on the future median annual population growth rates. The survival improvement is not sufficient to reduce the declining population trend for SR steelhead. Additional survival improvement ranging from 44% to 333%, depending on assumptions and aggregate run, would be necessary to achieve the recovery indicator criterion of lambda greater than or equal to 1.0.

The effect of the proposed action on the ability to meet the recovery indicator criterion was not affected by the pseudopopulation sensitivity analysis because the pseudopopulations were assumed to have the same abundance trends as the A-run and B-run aggregates. The use of pseudopopulations did increase the risk of extinction, compared with that of the aggregates, but not significantly. For example, the highest estimate of the survival improvement necessary to meet the survival indicator criteria was 152% for the B-run aggregate and 165% for the B-run pseudopopulation (Table 9.7-11). In all cases, it was more difficult to meet the recovery

Table 9.7-11. Snake River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.72	0.83	1.50	1.61	0.78	0.91	0.93	1.94	1.58	3.60
A-Run Aggregate	0.74	0.85	1.44	1.54	0.80	0.93	0.85	1.74	1.44	3.14
A-Run Pseudopopulation[9]	0.74	0.85	1.44	1.54	0.80	0.93	0.96	1.93	1.44	3.14
B-Run Aggregate	0.74	0.84	1.56	1.67	0.80	0.90	1.18	2.52	1.92	4.33
B-Run Pseudopopulation[10]	0.74	0.84	1.56	1.67	0.80	0.90	1.25	2.65	1.92	4.33

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents SR spring/summer chinook low estimate.
[4] High represents SR spring/summer chinook high estimate.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Pseudopopulation is 10% of A-run aggregate abundance
[10] Pseudopopulation is 33% of B-run aggregate abundance

indicator criteria than the survival indicator criteria, so the overall needed survival change was not affected by the use of pseudopopulations.

9.7.2.6.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the RPA's ability to achieve survival and recovery indicator criteria. Substantial comments primarily questioned 1) the estimates of hydrosystem survival associated with the RPA (addressed in Section 6.2), 2) the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed in Section 6.3.6.3 with one new and one modified method of estimating the expected change for SR spring/summer chinook; the application of that survival change to steelhead was not questioned), 3) the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% that of wild-origin spawners (addressed in Section 6.3.2.3), and 4) the analytical assumption that all survival changes are achieved instantaneously. This last point is addressed below.

The simple analytical approach used in this biological opinion does assume that all survival changes are instantaneous (McClure et al. 2000c). To the extent that improvements are implemented gradually, the analysis underestimates the survival change that will ultimately be required. The magnitude of the additional change for SR steelhead is unknown. The potential effect of delay on SR steelhead may be inferred from analyses of three chinook salmon ESUs. NMFS evaluated a 10-year delay in implementing the hydrosystem component of the RPA and in achieving any survival improvements in other life stages (Appendix A) for SR spring/summer chinook (Section 9.7.2.1.5), SR fall chinook (Section 9.7.2.2.5), and UCR spring chinook (Section 9.7.2.3.5). These analyses also assumed that there has been no change from average 1980-to-most-recent-year survival as a result of current hydrosystem operations (including those of the PUD projects for UCR spring chinook) and harvest reductions (SR fall chinook), which are already implemented. The results indicated that these pessimistic assumptions would result in a substantially greater necessary survival improvement at the end of 10 years for UCR spring chinook (highest necessary change [178%] increased to 368%). They also indicated that a much smaller effect would occur for SR fall chinook (highest necessary change [44%] increased to 69%). Results for the SR spring/summer chinook index stocks were intermediate. NMFS qualitatively considers possible inferences from these chinook ESUs to SR steelhead in making a jeopardy determination.

This analysis also contains assumptions that may make the results overly pessimistic. Three of these are the analytical assumptions that all spawning aggregates behave as independent populations, that all supplementation programs cease immediately, and that background survival will continue as it has from 1980 to the present. These assumptions are discussed in Section 6.3.6.5.

9.7.2.6.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-11 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for SR steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above Lower Granite Dam. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. The RPA also provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.7 Upper Columbia River Steelhead

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Specifically, Chief Joseph and Grand Coulee dams block substantial portions of the historical spawning range. Habitat problems are largely related to irrigation diversions and hydroelectric dams, as well as degraded riparian and instream habitat from urbanization and livestock grazing. Hatchery fish are widespread and escape to spawn naturally throughout the region. The relative contribution of these hatchery spawners to natural production rates is unknown.

In this section, NMFS quantitatively evaluates the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.7.1 Populations Evaluated

Ford et al. (1999) identified at least three populations comprising this ESU: the Wenatchee River population, the Methow River population, and the Entiat River population. Ford et al. (1999) identified interim recovery goals for each population and included the criterion that all three must meet these goals for delisting. Steelhead spawner estimates are available only from dam counts, so Cooney (2000) evaluated the Methow River population based on Wells Dam counts and evaluated the combined Wenatchee River and Entiat River populations based on differences between Rock Island and Wells Dam counts. McClure et al. (2000b,c) analyzed the aggregate ESU based on Rock Island Dam counts.

9.7.2.7.2 Necessary Survival Change

McClure et al. (2000b,c) and Cooney (2000) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. Cooney (2000) also estimated the change from base period lambda necessary to achieve $\geq$50%

likelihood of meeting the Methow and combined Wenatchee/Entiat population interim recovery abundance levels (Ford et al. 1999) in 48 and 100 years. NMFS (Appendix A) estimated the survival change necessary to meet the alternative recovery indicator criterion of lambda $\geq$ 1.0 for the aggregate run, using lambda estimates from McClure et al. (2000b) and methods described in Appendix A. The CRI analytical approach (McClure et al. 2000c) and the QAR analytical approach (Cooney 2000) produce different estimates of necessary survival changes for these populations. NMFS considers both approaches to have advantages and disadvantages and uses results from both to define a range of necessary survival change.

9.7.2.7.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from base period will continue indefinitely. However, the Basinwide Recovery Strategy identifies implementation of the Mid-Columbia HCP at five PUD projects as a probable element of recovery planning that is, therefore, included in the analysis, consistent with step 4 of the jeopardy analysis framework described in Section 1.3. The Basinwide Recovery Strategy estimates that this action will be implemented within 2 to 5 years. Cooney (2000, Table 20) estimates that implementation of the HCP will improve survival 23% for the Wenatchee population, 33% for the Entiat population, and 38% for the Methow population.

In addition, in Section 6.3.7.3, NMFS estimates that current FCRPS hydrosystem survival, combined with implementation of the Mid-Columbia HCP and harvest reductions, represents a 12%-to-43% improvement over the average survival rate influencing base period adult returns. The range represents different effects of the HCP on each population and a range of estimates of the historical differential post-Bonneville survival (D = 0.8 to D = 1.0) in years when fish were transported from McNary Dam. Implementing the hydrosystem component of the RPA will proportionally increase adult survival through the FCRPS projects beyond the current level by an additional 1.6%, based on information in Table 9.7-5. The hydrosystem component of the RPA is also expected to proportionally increase juvenile survival to below Bonneville Dam by 15.2% (Table 9.7-5; Appendix A). The product of the proportional survival improvements associated with the current conditions, implementation of the HCP, and implementation of the hydrosystem RPA results in an expected survival improvement of 31% to 68% (1.31 to 1.68 times the average base period survival rate), as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival (other than those associated with the HCP; Cooney 2000), estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.7.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.7.4 Additional Necessary Survival Changes

Table 9.7-12 shows the effect of the 31%-to-68% survival rate increase expected from the hydrosystem component of the RPA on the future median annual population growth rates for the Methow and Wenatchee/Entiat populations and the aggregate ESU. Because different methods were used to estimate the population requirements and the aggregate ESU requirements, differences may be a result of either the analytical method or the scale of the analysis. Low estimates of the population growth rate indicate that it will continue to be negative after HCP implementation and continuation of the proposed action. High estimates indicate, however, that the Methow River and Wenatchee/Entiat River population growth rate will be positive. No additional survival improvements are necessary for Methow and Wenatchee/Entiat populations under the most optimistic estimates. For all other cases, however, additional survival improvements ranging from 26% to 193% (1.26 to 2.93 times the average base period survival rate) will be necessary to meet the recovery indicator criteria.

Table 9.7-12. Upper Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	**Low[1]**	**High[2]**	**Low[3]**	**High[4]**	**Low[5]**	**High[6]**	**Low[7]**	**High[8]**	**Low[7]**	**High[8]**
UCR Steelhead Aggregate - CRI	0.69	0.83	1.39	1.59	0.75	0.94	1.02	2.36	1.26	2.93
Methow - QAR	0.81	0.97	1.48	1.68	0.90	1.11	0.69	1.46	0.92	2.10
Wenatchee/Entiat - QAR[9]	0.85	0.94	1.31	1.49	0.91	1.04	0.75	1.27	1.00	1.67

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam .
[4] High represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Expected survival change is based on the Wenatchee estimate of HCP survival increase (Cooney 2000 Table 20). Entiat estimate from same source is higher.

9.7.2.7.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, UCR steelhead. However, three comments of particular relevance were that NMFS should not assume that the Mid-Columbia HCP will be implemented and achieve its survival goals within the time described in the Basinwide Recovery Strategy; that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously; and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners. As described in Section 6.3.6.5, NMFS considers the full range of hatchery spawner effectiveness in this biological opinion.

The first comment applies to implementation of the proposed Mid-Columbia HCP. CRITFC believes that anticipated HCP survival rates will not be achieved at all five PUD dams for at least 10 years because long-term gas-abatement projects are needed to achieve the necessary spill levels. NMFS agrees that there is some uncertainty about the exact schedule for achieving all survival improvements anticipated in the HCP, but the proposed HCP for the Chelan and Douglas PUDs and the draft EIS anticipate that the survival improvements will be achieved by the end of Phase I (2003). If this does not occur, it is reasonable to anticipate additional changes under the terms of the proposed HCP.

Regardless of the exact implementation schedule, the analysis described above does assume that HCP and hydrosystem RPA survival improvements are achieved immediately. NMFS conducted a sensitivity analysis on the effect of a 10-year delay in implementing *any* survival improvements over the base period average survival rate for UCR spring chinook (Section 6.3.3.5; Appendix C). Under this worst-case scenario, the CRI estimate of necessary survival change for the Wenatchee population increased significantly from the estimate that assumed immediate implementation. This extreme scenario is unlikely, since some improvements associated with the HCP have already been achieved, but NMFS considers the implications of delayed implementation qualitatively in reaching jeopardy conclusions for this ESU.

This analysis contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately and that background survival will continue as it has since 1980. These assumptions are discussed in Section 6.3.7.5.

9.7.2.7.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management, other than effects anticipated in the HCP. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-12 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for Upper Columbia River steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above the upper-most dam for each population. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.8 Middle Columbia River Steelhead

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development. Pelton Dam on the Deschutes River blocks access to historical spawning areas, and there are numerous minor blockages from smaller dams and impassable culverts throughout the region. In addition, the genetic integrity of the ESU is threatened by past and present hatchery practices. Hatchery fish are widespread and escape to spawn naturally throughout the region, so that adults of hatchery origin make up a substantial portion of the spawning population in several basins (e.g., the Umatilla and Deschutes rivers).

In this section, NMFS evaluates the action-area effects associated with the hydrosystem component of the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

9.7.2.8.1 Populations Evaluated

NMFS evaluated four spawning aggregations of MCR steelhead. The Yakima River aggregation passes through four FCRPS projects, the Umatilla River aggregation passes through three

FCRPS projects, and the Deschutes River and Warm Springs aggregations pass through two FCRPS projects. NMFS has not yet determined which, if any, of these spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the four aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.8.2 Necessary Survival Change

McClure et al. (2000b) described changes from the 1980-to-1994 (Yakima and Warm Springs) or 1980-to-1986 (Deschutes and Umatilla) median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from the 1980-to-1994/1996 lambda necessary to meet the recovery indicator criterion of lambda $\geq$1.0. Details of these estimates are found in Appendix A.

9.7.2.8.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns in the base period will continue indefinitely. However, in Section 6.3.8.3, NMFS estimates that current survival of the Yakima River spawning aggregation represents a -9% to +4% improvement from the average survival rate influencing 1980-to-1994 adult returns. NMFS estimated a 14% increase for the Umatilla spawning aggregation and a 7% increase for the Deschutes and Warm Springs spawning aggregations. These estimates represent a combination of reduced harvest rates, which NMFS assumes equal to the SR A-run steelhead harvest reductions, and increased juvenile passage survival. Rationale and methods are described in Section 6.3.8.3 and Appendix A.

Implementing the hydrosystem component of the RPA will proportionally increase adult survival beyond the current level by an additional 1.7% to 3.%%, depending on the number of FCRPS dams each spawning aggregate passes (Table 9.7-5). The hydrosystem component of the RPA will also increase juvenile survival to below Bonneville Dam by 11.7% to 15.2%, depending on the number of dams passed (Table 9.7-5). The product of the proportional survival improvements associated with the current conditions, including harvest reductions, and the hydrosystem RPA actions results in an expected survival improvement of 9% to 24% (1.09 to 1.24 times the average 1980-to-1994 survival rate) for the Yakima stock; 33% (1.33 times the average 1980-to-1996 survival rate) for the Umatilla stock; and 22% (1.22 times the average base period survival rate) for the Deschutes and Warm Springs stocks, as described in Appendix A.

No other quantifiable survival rates changed significantly between the average base period and the current condition. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in these survival rates is included in this quantitative analysis. In Section 9.7.2.8.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.8.4 Additional Necessary Survival Changes

Table 9.7-13 shows the effect of the 9% to 33% survival rate change expected from the hydrosystem component of the RPA on the future median annual population growth rates for the four MCR steelhead spawning aggregations in this analysis. Population growth rates are expected to be negative for all aggregations except the Yakima River aggregation (lambda is 1.03 to 1.08). Additional survival changes of 31% to 226% (1.31 to 3.26 times the base period average survival rates) are necessary to meet recovery indicator criteria for the Deschutes, Warm Springs, and Umatilla spawning aggregations. No additional improvement is needed for the Yakima River aggregation to meet the survival and recovery indicator criteria.

Table 9.7-13. Mid-Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.77	0.84	1.21	1.25	0.80	0.88	N/A	N/A	1.92	3.18
Deschutes R Sum	0.77	0.84	1.22	1.22	0.80	0.87	1.28	2.06	2.02	3.26
Warm Springs NFH Sum	0.91	0.91	1.22	1.22	0.94	0.94	1.16	1.19	1.36	1.36
Umatilla R Sum	0.90	0.90	1.33	1.33	0.95	0.95	0.88	0.86	1.31	1.27
Yakima R Sum	1.01	1.04	1.09	1.24	1.03	1.08	0.81	0.92	0.67	0.85

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low for Yakima R. represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High for Yakima R. represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.8.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, MCR steelhead. However, two comments of particular relevance were that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously, and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners. As described in Section 6.3.8.5, NMFS considers the full range of hatchery spawner effectiveness in this biological opinion.

The simple analytical approach used in this biological opinion assumes that all survival changes are instantaneous (McClure et al. 2000c). To the extent that improvements are implemented gradually, the analysis underestimates the survival change that will ultimately be required. The magnitude of the additional change for MCR steelhead is unknown. The potential effect of delay on MCR steelhead may be inferred from analyses of three chinook salmon ESUs. NMFS evaluated a 10-year delay in implementing the hydrosystem component of the RPA and in achieving any survival improvements in other life stages (Appendix A) for SR spring/summer chinook (Section 9.7.2.1.5), SR fall chinook (Section 9.7.2.2.5), and UCR spring chinook (Section 9.7.2.3.5). The analyses also assumed that there has been no change from average-1980 to most-recent-year survival as a result of current hydrosystem operations (including those of the PUD projects for UCR spring chinook) and harvest reductions (SR fall chinook), which are already implemented. The results indicated that these pessimistic assumptions would result in a substantially greater necessary survival improvement at the end of 10 years for UCR spring chinook (highest necessary change [178%] increases to 368%). They also indicated that a much smaller effect would occur for SR fall chinook (highest necessary change [44%] increased to 69%). Results for the SR spring/summer chinook index stocks were intermediate. NMFS qualitatively considers possible inferences from these chinook ESUs to MCR steelhead in making a jeopardy determination.

This analysis also contains assumptions that may make the results overly pessimistic. Three of these are the analytical assumptions that all spawning aggregates behave as independent populations; that all supplementation programs cease immediately; and that background survival will continue as it has from 1980 to the present. These assumptions are discussed in Section 6.3.8.5.

9.7.2.8.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-13 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for MCR steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival above the upper dam passed by each stock. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with those expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive, actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.9 Upper Willamette River Steelhead

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UWR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the loss of habitat due to inundation or blockages resulting from the construction of numerous tributary hydroelectric and irrigation facilities; and habitat degradation due to timber harvest, development (agricultural, municipal, and industrial), dam development, and river channelization and dredging. Many of these activities result in poor water quality, high sediment loads, altered thermal regimes, and a large reduction in available spawning and rearing habitat. Overharvest and hatchery production have also contributed to the decline of this ESU.

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.9.1 Populations Evaluated

NMFS quantitatively evaluated four spawning aggregations: the Molalla, North Santiam, South Santiam, and Calapooia river populations. NMFS has not yet determined which, if any, of the UWR steelhead spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the four aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.9.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the four spawning aggregations. NMFS also estimated the change from base period lambda necessary to achieve

≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

9.7.2.9.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for UWR steelhead, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. NMFS cannot identify any significant changes in survival rates under the RPA compared to those that influenced the base period adult returns because survival changes due to implementing the RPA can be quantified only for species that migrate past mainstem dams (which excludes UWR steelhead). NMFS was also unable to quantify potential changes in egg-to-smolt survival, estuary survival, or adult survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 9.7.2.9.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.9.4 Additional Necessary Survival Changes

Table 9.7-14 shows that the RPA is not expected to increase the population survival rate; negative median annual population growth rates are expected to continue for each of the four UWR steelhead spawning aggregations. Survival improvements needed to meet the recovery indicator criteria range from 30% to 108% (1.30 to 2.08 times the average base period survival rates).

9.7.2.9.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, UWR steelhead. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately and that the background survival rate will continue as it has since 1980. These points are addressed in Section 6.3.1.5.

9.7.2.9.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam, or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-14 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Table 9.7-14. Upper Willamette River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

							Additional Change In Survival Needed to Achieve:			
	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
Spawning Aggregation	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.88	0.92	1.00	1.00	0.88	0.92	1.13	1.39	1.37	1.69
Molalla	0.84	0.91	1.00	1.00	0.84	0.91	1.34	1.96	1.45	2.08
N Santiam R	0.89	0.92	1.00	1.00	0.89	0.92	1.20	1.34	1.42	1.58
S Santiam	0.87	0.94	1.00	1.00	0.87	0.94	1.06	1.50	1.30	1.78
Calapooia	0.93	0.93	1.00	1.00	0.93	0.93	1.53	1.53	1.36	1.36

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for UWR steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above Willamette Falls). Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.10 Lower Columbia River Steelhead

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of LCR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development. Upstream passage is blocked by dams on the Lewis, Clackamas, Sandy, and Hood rivers, and there are minor blockages (such as impassable culverts) throughout the region. Mudflows from the eruption of Mt. St. Helens (1980) significantly disrupted and degraded habitat in the South Fork Toutle and Green rivers, as did post-eruption dredging, diking, and bank protection works in the Cowlitz River below its confluence with the Toutle River. In addition, the genetic integrity of the ESU is threatened by past and present hatchery practices. Each year, hatcheries release approximately 3 million steelhead smolts in basins occupied by the ESU (Busby et al. 1996). In many basins, hatchery strays compose most of the spawning population.

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.10.1 Populations Evaluated

NMFS quantitatively evaluated seven spawning aggregations below Bonneville Dam. Adequate information was not available for similar analyses for spawning aggregations above Bonneville Dam. NMFS has not yet determined which, if any, of the LCR steelhead spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the seven aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.10.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rates (lambda) that are necessary to meet the survival indicator criteria for the seven subbasin spawning aggregations. NMFS also estimated the change from the base period lambda necessary to achieve $\geq$50% likelihood of meeting the recovery indicator criterion of lambda $\geq$1.0 for each aggregation. Details of these estimates are provided in Appendix A.

9.7.2.10.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for the seven spawning aggregations of LCR steelhead, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns for winter steelhead in the Clackamas, Green, Kalama, Sandy, and Toutle rivers will continue indefinitely. Adult harvest rates for summer steelhead in the Clackamas and Kalama subbasins have changed, however. NMFS assumes that the size of the change from the average rate over the base period is similar to that estimated for other summer-run steelhead in the Columbia basin. The A-run harvest rate reduction resulted in a survival increase of 7.2% for SR steelhead (Section 6.3.6.3).

Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses pass this project. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 9.7.2.10.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.10.4 Additional Necessary Survival Changes

Table 9.7-15 shows that the RPA is expected to increase the survival rate of two of the LCR steelhead spawning aggregations because of harvest rate reductions. Negative median annual population growth rates are expected to continue for all seven aggregations, however. Survival improvements needed to meet the survival and recovery indicator criteria range from 13% to 376% (1.13 to 4.76 times the average base period survival rates).

Table 9.7-15. Lower Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.80	0.91	1.00	1.00	0.80	0.91	N/A	N/A	1.53	2.71
Aggregations Above Bonneville Dam:										
(insufficient information for analysis)										
Aggregations Below Bonneville Dam:										
Clackamas Sum	0.73	0.83	1.07	1.07	0.74	0.84	1.75	3.34	2.44	4.76
Clackamas Win	0.76	0.88	1.00	1.00	0.76	0.88	1.35	2.57	1.75	3.43
Green River Win	0.90	0.90	1.00	1.00	0.90	0.90	1.80	1.80	1.58	1.58
Kalama Sum	0.77	0.91	1.07	1.07	0.78	0.92	1.09	2.50	1.51	3.67
Kalama River Win	0.90	0.97	1.00	1.00	0.90	0.97	1.00	1.14	1.13	1.58
Sandy Win	0.85	0.91	1.00	1.00	0.85	0.91	1.19	1.63	1.49	2.08
Toutle Win	0.88	0.88	1.00	1.00	0.88	0.88	1.30	1.30	1.81	1.81

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.10.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, LCR steelhead. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980. These points are addressed in Section 6.3.1.5.

9.7.2.10.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-15 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for LCR steelhead. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival and estuary survival. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.11 Columbia River Chum Salmon

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of CR chum salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include water withdrawals, conveyance, storage, and flood control, resulting in insufficient flows, stranding, juvenile entrainment, and instream temperature increases; logging and agriculture (loss of large woody debris, sedimentation, loss of riparian vegetation, and habitat simplification); mining (especially gravel removal, dredging, and pollution); urbanization (stream channelization, increased runoff, pollution, and habitat simplification); development of many small hydropower facilities in lower river areas; passage mortality at Bonneville Dam; and substantial habitat loss in the Columbia River estuary and associated areas.

In this section, NMFS quantitatively evaluates the action-area effects associated with the RPA and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the RPA and other likely actions could increase annual population growth rates such that survival and recovery are likely.

9.7.2.11.1 Populations Evaluated

NMFS quantitatively evaluated six spawning aggregations below Bonneville Dam. NMFS has not yet determined which, if any, of the CR chum salmon spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the six aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

9.7.2.11.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the six spawning aggregations. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

9.7.2.11.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for CR chum salmon, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses passes this project. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat management actions. Instead, in Section 9.7.2.11.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

9.7.2.11.4 Additional Necessary Survival Changes

Table 9.7-16 shows that the RPA is not expected to increase spawning aggregation survival rates. Negative median annual population growth rates are expected to continue for two of the CR chum salmon spawning aggregations (mainstem Grays River and Hamilton Creek). An additional survival improvement of from 18% to 36% (1.18 to 1.36 times the average base period survival rates) is needed to meet the recovery indicator criteria for these two spawning aggregations.

Table 9.7-16. Columbia River chum salmon estimates of current and expected median annual population growth rate (lambda), expected survival change from RPA, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	1.04	1.04	1.00	1.00	1.04	1.04	N/A	N/A	0.88	0.88
Aggregations Above Bonneville Dam:										
(insufficient information for analysis)										
Aggregations Below Bonneville Dam:										
Grays R west fork	1.23	1.23	1.00	1.00	1.23	1.23	N/A	N/A	0.47	0.47
Grays R mouth to head	0.96	0.96	1.00	1.00	0.96	0.96	N/A	N/A	1.18	1.18
Hardy Creek	1.05	1.05	1.00	1.00	1.05	1.05	N/A	N/A	0.85	0.85
Crazy Johnson	1.16	1.16	1.00	1.00	1.16	1.16	N/A	N/A	0.59	0.59
Hamilton	0.92	0.92	1.00	1.00	0.92	0.92	N/A	N/A	1.36	1.36
Hamilton Springs	1.11	1.11	1.00	1.00	1.11	1.11	N/A	N/A	0.68	0.68

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

9.7.2.11.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations comments that NMFS' analysis in the July 27, 2000, Draft Biological Opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the RPA would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, CR chum salmon. In fact, this analysis contains an assumption that may make the results overly pessimistic. For example, NMFS assumes that the background survival rate will continue as it has since 1980. This point was addressed in Section 6.3.1.5.

9.7.2.11.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam or changes in survival in other life stages that result from habitat management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 9.7-16 are likely to be achieved through recent or anticipated future actions that affect other life stages. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat management actions. Instead, in Section 9.7.2.11.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in Section 1.3 of the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for CR chum salmon. The improvements will probably be expressed as changes from the average base period, egg-to-smolt survival and estuary survival. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA provides mechanisms for pursuing additional, more intensive actions within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.12 Snake River Sockeye Salmon

Evaluation of the species-level effects of the RPA requires placing the action-area effects of the RPA in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR sockeye salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include tributary hydropower and irrigation storage projects that block or restrict fish passage, water withdrawals that dewater streams, and unscreened diversions.

Because the abundance of SR sockeye salmon is extremely low, the risk of extinction cannot be calculated using the methods that NMFS employs in this biological opinion. However, the risk is undoubtedly very high. Other factors that affect elements of critical habitat also contribute to this ESU's high risk of extinction (summarized in Section 4.1 and Appendix C), but the FCRPS is a significant factor. The high risk of extinction is partially mitigated by a captive breeding program, funded by the Action Agencies, which provides some assurance that SR sockeye salmon will not go extinct in the immediate future. However, long-term survival and recovery in the wild require substantial increases in survival throughout the life cycle.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that the habitat and hatchery actions described in the relevant sections of Volume 2 of the Basinwide Recovery Strategy provide enough potential for offsite mitigation to achieve the additional survival improvements for SR sockeye salmon. The RPA includes a better-defined commitment by the Action Agencies to fund offsite mitigation activities than did the biological assessment. The RPA also calls for performance standards, a schedule, and a process for ensuring that the offsite mitigation activities of the Action Agencies combined with the activities expected of other Federal and non-Federal entities will achieve necessary survival improvements. Further, the RPA calls for mechanisms for pursuing additional, more intensive actions, including possible dam breaching, within the framework for implementation and progress review. Although it is not possible at this time to quantitatively evaluate the effects of these actions on survival in other life stages, these factors, taken together, indicate that the necessary survival improvements are likely to occur.

9.7.2.13 Summary—Effects of RPA on Biological Requirements Over Full Life Cycle

The ESU-specific analyses in Sections 9.7.2.1 through 9.7.2.12 include both quantitative and qualitative assessments.[1] The quantitative analyses show that recent survival changes continued into the future, plus additional survival changes expected to result from implementation of the RPA, will increase the likelihood of meeting the survival and recovery indicator criteria for stocks that pass through one or more FCRPS projects. Summer steelhead stocks throughout the basin, including two of the spawning aggregations in the LCR steelhead ESU, will also benefit from the recent harvest reduction for A-run steelhead in the Snake River basin. However, for all ESUs, many stocks will need additional survival improvements beyond those expected from the RPA. For most ESUs, the additional improvements range from a few percentage points to two orders of magnitude (Table 9.7-17).[2] For LCR chinook salmon spawning in the Lewis and Clark River, a survival improvement of over 1,000 times is needed.

NMFS' qualitative assessment considers the extent to which the RPA affects the capacity of critical habitat to provide biological requirements for listed fish. As described in Sections 4, 5, and 6, a number of factors affect current population trends of Columbia River basin salmonids. The hydro actions in the RPA address mortality in the action area. Actions in habitat, harvest, and hatcheries address human-caused factors that limit survival and recovery elsewhere in the life cycle. For example, habitat actions include protecting productive habitat, restoring tributary flows, screening and combining water diversions, reducing passage obstructions, and improving or restoring degraded habitat (Table 9.7-18). The Federal agencies will focus these near-term actions on priority subbasins for each ESU. Hatchery reforms expected to reduce adverse interactions with wild fish include developing new, local broodstocks (and eliminating inappropriate broodstocks) and managing the number of hatchery fish allowed to spawn

[1]Quantitative assessments are not possible for SR sockeye salmon.

[2] Critical assumptions that influence results for each ESU are discussed in the preceding sections.

Table 9.7-17. Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change			
Spawning Aggregation	**Low**	**High**		
Snake River Spring/Summer Chinook				
Aggregate ESU	46	89		
Index Stocks				
Bear Valley/Elk Creeks	0	0		
Imnaha River	26	66		
Johnson Creek	0	0		
Marsh Creek	0	12		
Minam River	0	28		
Poverty Flats	0	0		
Sulphur Creek	0	5		
Additional Spawning Aggregations				
Alturas Lake Ck	168	186	*	Based only on Lambda $\geq$ 1.0
American R	11	19	*	Based only on Lambda $\geq$ 1.0
Big Sheep Ck	29	58	*	Based only on Lambda $\geq$ 1.0
Beaver Cr	0	0	*	Based only on Lambda $\geq$ 1.0
Bushy Fork	0	0	*	Based only on Lambda $\geq$ 1.0
Camas Cr	4	11	*	Based only on Lambda $\geq$ 1.0
Cape Horn Cr	0	0	*	Based only on Lambda $\geq$ 1.0
Catherine Ck	50	131	*	Based only on Lambda $\geq$ 1.0
Catherine Ck N Fk	4	12	*	Based only on Lambda $\geq$ 1.0
Catherine Ck S Fk	101	114	*	Based only on Lambda $\geq$ 1.0
Crooked Fork	0	0	*	Based only on Lambda $\geq$ 1.0
Grande Ronde R	58	142	*	Based only on Lambda $\geq$ 1.0
Knapp Cr	22	30	*	Based only on Lambda $\geq$ 1.0
Lake Cr	0	0	*	Based only on Lambda $\geq$ 1.0
Lemhi R	0	0	*	Based only on Lambda $\geq$ 1.0
Lookingglass Ck	102	225	*	Based only on Lambda $\geq$ 1.1
Loon Ck	0	0	*	Based only on Lambda $\geq$ 1.0
Lostine Ck	15	44	*	Based only on Lambda $\geq$ 1.0
Lower Salmon R	7	14	*	Based only on Lambda $\geq$ 1.0
Lower Valley Ck	3	10	*	Based only on Lambda $\geq$ 1.0
Moose Ck	0	0	*	Based only on Lambda $\geq$ 1.0
Newsome Ck	0	0	*	Based only on Lambda $\geq$ 1.0

Table 9.7-17 (Continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change			
Spawning Aggregation	Low	High		
Red R	10	18	*	Based only on Lambda ≥ 1.0
Salmon R E Fk	0	2	*	Based only on Lambda ≥ 1.0
Salmon R S Fk	0	0	*	Based only on Lambda ≥ 1.0
Secesh R	0	0	*	Based only on Lambda ≥ 1.0
Selway R	8	15	*	Based only on Lambda ≥ 1.0
Sheep Cr	97	110	*	Based only on Lambda ≥ 1.0
Upper Big Ck	0	0	*	Based only on Lambda ≥ 1.0
Upper Salmon R	13	21	*	Based only on Lambda ≥ 1.0
Upper Valley Ck	0	0	*	Based only on Lambda ≥ 1.0
Wallowa Ck	42	51	*	Based only on Lambda ≥ 1.0
Wenaha R	14	66	*	Based only on Lambda ≥ 1.0
Whitecap Ck	14	22	*	Based only on Lambda ≥ 1.0
Yankee Fork	26	35	*	Based only on Lambda ≥ 1.0
Yankee West Fk	0	0	*	Based only on Lambda ≥ 1.0
<u>Snake River Fall Chinook</u>				
Aggregate	0	44		
<u>Upper Columbia River Spring Chinook</u>				
ESU Aggregate - CRI	32	58		
Methow River-QAR	24	41		
Entiat River-QAR	36	55		
Wenatchee R.-QAR	51	116		
Methow River-CRI	32	90		
Entiat River-CRI	32	119		
Wenatchee R.-CRI	84	178		
<u>Upper Willamette River Chinook</u>				
McKenzie River above Leaburg Dam	9	65		

Table 9.7-17 (Continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

Spawning Aggregation	Needed Survival Change Low	Needed Survival Change High	
Lower Columbia River Chinook			
Aggregations Above Bonneville Dam:			
(Insufficient information for analysis)			
Aggregations Below Bonneville Dam:			
Bear Creek	114	213	
Big Creek	31	97	
Clatskanie	193	312	
Cowlitz Tule	33	99	* Based only on recovery metric.
Elochoman	4	56	* Based only on recovery metric.
Germany	30	95	* Based only on recovery metric.
Gnat	107	195	
Grays Tule	76	164	* Based only on recovery metric.
Kalama Spring	87	180	* Based only on recovery metric.
Kalama	6	58	* Based only on recovery metric.
Klaskanine	130	227	
Lewis R Bright	5	11	* Based only on recovery metric.
Lewis Spring	46	120	* Based only on recovery metric.
Lewis, E Fk Tule	3	3	* Based only on recovery metric.
Lewis and Clark	934	1,493	
Mill Fall	144	258	
Plympton	21	82	
Sandy Late	7	9	
Skamokawa	105	208	* Based only on recovery metric.
Youngs	573	732	
Snake River Steelhead			
ESU Aggregate	58	260	
A-Run Aggregate	44	214	
A-Run Pseudopopulation	44	214	
B-Run Aggregate	92	333	
B-Run Pseudopopulation	92	333	

Table 9.7-17 (Continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Upper Columbia River Steelhead			
ESU Aggregate - CRI	26	193	
Methow - QAR	0	110	
Wenatchee/Entiat - QAR	0	67	
Mid-Columbia River Steelhead			
ESU Aggregate	92	218	* Based only on recovery metric.
Deschutes R Sum	102	226	
Warm Springs NFH Sum	36	36	
Umatilla R Sum	31	27	
Yakima R Sum	0	0	
Upper Willamette River Steelhead			
ESU Aggregate	37	69	
Molalla	45	108	
N Santiam R	42	58	
S Santiam	30	78	
Calapooia	53	53	
Lower Columbia River Steelhead			
ESU Aggregate	53	171	* Based only on recovery metric.
Aggregations Above Bonneville Dam:			
(Insufficient information for analysis)			
Aggregations Below Bonneville Dam:			
Clackamas Sum	144	376	
Clackamas Win	75	243	
Green River Win	80	80	
Kalama Sum	51	267	
Kalama River Win	13	58	

Table 9.7-17 (Continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the RPA. Low and High estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Sandy Win	49	108	
Toutle Win	81	81	
Columbia River Chum Salmon			
ESU Aggregate	0	0	* Based only on recovery metric.
Aggregations Above Bonneville Dam:			
(Insufficient information for analysis)			
Aggregations Below Bonneville Dam:			
Grays R west fork	0	0	
Grays R mouth to head	18	18	
Hardy Creek	0	0	
Crazy Johnson	0	0	
Hamilton	36	36	
Hamilton Springs	0	0	

naturally. The harvest actions will cap harvest rates at current levels, allowing time for other recovery measures to take effect.

Each set of actions is expected to benefit Columbia basin salmonids, although measures that address hydrosystem passage will clearly benefit the upper river chinook salmon and steelhead ESUs, SR sockeye salmon, and MCR steelhead more than the lower river ESUs. In the short term, benefits to the lower river ESUs will result primarily from the habitat, harvest, and hatchery actions. In the long term, ongoing studies may link the effects of FCRPS flow management to elements of critical habitat in the estuary and plume. These studies may lead to additional hydro actions (i.e., through comprehensive 5- and 8-year check-ins [Sections 9.1.5 and 9.5]) that provide high survival benefits to all 12 ESUs.

Table 9.7-18. Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR spring/summer chinook	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**Inriver migrants:** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 8 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage** **Transported fish:** **- Potential for reduced delayed mortality** *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Potential habitat degradation in the plume** *- Hatchery reforms may reduce adverse interactions with wild fish* *- Potential reduction in incidental take to reduce ocean harvest*	**- Expected 6% increase in survival during passage through 8 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR fall chinook	**Inriver migrants:** **- Flows and water quality (temperature) improve during summer and early fall in the Snake River due to additional cold water releases from Dworshak Reservoir** **- Inriver survival increases by ~5% due to passage improvements at 8 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and increased summer flows** **- Potential for reduced delayed mortality due to FCRPS passage** **Transported fish:** **-Improved transportation due to extended barging** **-Potential for reduced delayed mortality** *- Hatchery reforms may reduce adverse interactions with wild fish*		*- Acquire, protect, and restore high quality estuarine habitat* *- Hatchery reforms may reduce adverse interactions with wild fish* *- Potential reduction in incidental take to reduce ocean harvest*	**-Expected 11% increase in survival during passage through 8 FCRPS projects** **- Water quality (temperature) improves during summer and early fall in the Snake River due to additional cold water releases from Dworshak Reservoir** **- Potential indirect improvement in spawning rate success** *- Potential reduction in incidental take to reduce mainstem harvest*	**- Unknown effects of flow management on use of spawning habitat below Lower Granite, Little Goose, and Ice Harbor dams** *In the lower Snake mainstem:* *- Protect productive habitat* *- Address flow and passage problems* *- Improve/restore degraded habitat* *- Hatchery reforms may reduce adverse interactions with wild fish*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR spring chinook	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 4 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage** - Mortality due to passage past up to 5 PUD projects *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Potential habitat degradation in the plume** *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Expected 3% increase in survival during passage through 4 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** - Mortality due to passage past up to 5 PUD projects *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*
UWR chinook	*In the McKenzie subbasin:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill**	*- Acquire, protect, and restore high quality estuarine habitat* *- Hatchery reforms may reduce adverse interactions with wild fish* *- Potential reduction in incidental take to reduce ocean harvest*	*In the McKenzie subbasin:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	*In the McKenzie subbasin:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR chinook	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~5% due to passage past Bonneville Dam for a limited number of subbasin populations**	*- Acquire, protect, and restore high quality estuarine habitat* *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Expected 1-2% increase in survival during passage past Bonneville Dam for a limited number of subbasin populations** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill**	**- Access to and quantity and quality of habitat at Ives Island restricted by FCRPS flows** *In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Development	Adult Migration Corridor	Spawning Habitat
SR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**Inriver migrants:** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 8 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage** **Transported fish:** **- Potential for reduced delayed mortality** *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Potential habitat degradation in the plume**	**- Expected 5-6% increase in survival during passage through 8 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 4 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage** - Mortality due to passage past up to 5 PUD projects *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Potential habitat degradation in the plume**	**- Expected 3% increase in survival during passage through 4 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** - Mortality due to passage past up to 5 PUD projects *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
MCR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 4 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- Potential for reduced delayed mortality due to FCRPS passage**	**- Potential habitat degradation in the plume**	**- Expected 3% increase in survival during passage through 4 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Potential indirect improvement in spawning rate success** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*
UWR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** *- Hatchery reforms may reduce adverse interactions with wild fish*	*- Acquire, protect, and restore high quality estuarine habitat* *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR steelhead	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~4% due to passage improvements at Bonneville Dam for a limited number of subbasin populations**	**- Potential habitat degradation in the plume** *- Hatchery reforms may reduce adverse interactions with wild fish*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Expected 1% increase in survival during passage past Bonneville Dam for a limited number of subbasin populations** *- Potential reduction in incidental take to reduce mainstem harvest*	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*
CR chum	*In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*	**- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~5% due to passage past Bonneville Dam for a limited number of subbasin populations**	*- Acquire, protect, and restore high quality estuarine habitat*	**- Expected 1-2% increase in survival during passage past Bonneville Dam for a limited number of subbasin populations** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** *- Potential reduction in incidental take to reduce mainstem harvest*	**- Access to Hamilton Creek and Spring Channel improved by FCRPS flows** **- Access to, quantity of, and quality of habitat at Ives Island restricted by FCRPS flows** *In three priority subbasins:* *- Protect productive habitat* *- Address flow, passage, and screening problems* *- Improve/restore degraded habitat*

Table 9.7-18 (Continued). Summary of expected effects of RPA on critical habitat at species-level. Effects in action area shown in **bold**. Effects of offsite mitigation shown in *italics*.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR sockeye	N/A	**Inriver migrants:** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Survival increase due to passage improvements at 8 FCRPS projects** **- Expected 10% reduction in reservoir mortality due to predator control actions** **- Potential for reduced delayed mortality due to FCRPS passage** **Transported fish:** **- Potential for reduced delayed mortality**	**- Potential habitat degradation in the plume**	**- Expected ~1% increase in survival during passage through 8 FCRPS projects** **- Deflector optimization improves water quality (dissolved gas) during involuntary spill** *- Potential reduction in incidental take to reduce mainstem harvest*	N/A

9.7.3 Evaluation of Snake River Four-Dam Breach in Comparison to the RPA

Sections 9.7.1 and 9.7.2 reviewed the action-area and species-level effects of the hydrosystem components of the RPA, given concurrent expectations of survival in other life stages resulting from a continuation of current harvest rates and implementation of the Mid-Columbia HCP. For several ESUs, significant additional changes in survival are necessary, beyond those expected from implementation of the hydrosystem components of the RPA. Effects of expected improvements in other parts of the life cycle that were not captured in Section 9.7.1 are described in the Basinwide Recovery Strategy and are summarized in Section 9.7.2. The qualitative results of these sections suggest that a significant portion of the needed additional survival changes is likely to be achieved through ongoing federal activities and implementation of the off-site mitigation component of the RPA.

Regional debate in recent years has focused on the advisability of breaching four Snake River dams as an alternative to hydrosystem operations similar to those described in the RPA. This section provides an analysis of the effects of this action, to place the effects of the RPA in the context of the primary alternative option that has been discussed within the region.

This analysis is presented, in part, to demonstrate the effects of critical uncertainties on the estimated survival changes associated with breaching four Snake River dams. It is presented to support the possible future need to implement dam breaching following 5- and 10-year reviews (Section 9.5) of species' status, effectiveness of RPA measures, and new research results that may resolve some of the key uncertainties associated with effectiveness of breaching. This analysis supports the elements of the RPA that may require continued engineering and other preparations for possible future breaching.

9.7.3.1 Effects of Snake River Four-Dam Breach on Action Area Biological Requirements

In its report "Return to the River," the Independent Scientific Group (ISG 1996) calls for the reestablishment of "normative" ecosystem features of the Columbia and Snake rivers and tributaries that are essential to salmon restoration. The term "normative" describes a condition that provides "essential ecological conditions and processes needed to maintain diverse and productive salmonid populations." The ISG characterizes the normative river as a continuum of conditions ranging from slightly better than current at one end of the spectrum to nearly pristine on the other. The ISG asserts that only by approaching more normative ecosystem conditions would recovery goals for salmonids be attained. Moreover, sustained productivity will require a network of complex and interconnected habitats that are created, altered, and maintained by natural physical processes in freshwater, the estuary, and the ocean (ISG 1996).

Natural river drawdown of the four Federal hydroprojects on the lower Snake River could reestablish a continuum of riverine habitat. Drawdown to natural river level of the four lower Snake River reservoirs is expected to improve conditions for both juveniles and adults of some salmonid species by exposing more of the shoreline and allowing the river to redistribute gravel and nutrients, thereby restoring spawning, rearing, and feeding habitat. It is also expected to increase the connectivity of channel, groundwater, floodplain, and upland components of the catchment ecosystem and create more diverse, high-quality habitat, which is crucial for salmonid spawning, rearing, migration, maintenance of food webs, and predator avoidance (ISG 1996).

9.7.3.1.1 Dam Passage Survival During Removal and Transition Periods. The Corps has developed a tentative schedule for breaching the four lower Snake River dams (Corps 1999c [feasibility report/EIS and Appendix D]). After receiving congressional authorization, the Corps estimates that the project would be completed in 8 or 9 years, with drawdown of Lower Granite and Little Goose reservoirs in year 5 or year 6, and drawdown of Lower Monumental and Ice Harbor reservoirs in the following year. During this 2-year removal period, each of the four reservoirs would be drawn down to natural river level during the months of August through December. The Corps predicts a 3- to 8-year transition period after drawdown is complete, during which major changes in the riverine environment — such as sediment scour and redeposition and the redistribution of predators — would stabilize. During the transition period, mortality rates of juvenile and adult salmon and steelhead may be affected by these factors, as well as deviation from normal operations at the dams. For example, normal operations would not be possible during transition from full pool to riverine conditions (August to December). Turbines would operate at less than maximum efficiency, spill conditions would be altered, and transportation of fish would not be possible. All of these conditions could increase mortality of fall chinook and sockeye outmigrating during the 2-year removal period.

Under the Corps' drawdown plan in the draft feasibility report/EIS, turbines would be modified before the 2-year removal period so that they could be operated under the unusual low-head conditions for primary discharge while the reservoirs are lowered. As a result, up to 3 units per project would not be available during part of the preceding spring spill season, and the reduced powerhouse capacity could result in increased spill and potentially undesirable TDG levels in the river downstream. NMFS expects that these effects, if they occur, would be transitory and would most likely occur during May (Table 9.7-19).[3] Effects of elevated TDG could be severe if flows are unusually high while the powerhouse is running under reduced capacity.

[3] The analysis shown in Table 9.7-19 suggests that the Corps should schedule turbine retrofits such that work is completed by April 1 of each year, to minimize potential TDG problems.

Table 9.7-19. Estimated safe discharge[1] and probability of involuntary occurrence of flows exceeding this level under existing project capacities and under project capacities estimated to exist while the three low-capacity turbines are being replaced at each lower Snake River project.

	Current Conditions				Replacement-year Conditions			
	Total Safe Discharge	Probability of Exceedence (%)			Total Safe Discharge	Probability of Exceedence (%)		
Project	(kcfs)	April	May	June	(kcfs)	April	May	June
Lower Granite	178.8	0	2	2	126	8	25	27
Little Goose	162.3	4	6	8	110.4	22	41	33
Lower Monumental	162.7	4	6	8	105.1	29	45	21
Ice Harbor	198.9	0	0	2	161.4	4	8	8

[1] Safe discharge is the discharge that would result in 120% TDG downstream from each project assuming maximum powerhouse capacity and known project TDG characteristics.

Removal and Transition Period Effects on Juvenile Salmon. During the removal period, conditions at the dams (i.e., at juvenile bypass systems) would be outside the criteria of systems designed to improve the passage survival of migrating juvenile salmon and steelhead. By scheduling the dam breaching process between August and December, when relatively few juveniles are passing the projects, the Corps would minimize potential adverse effects on most Snake River ESUs. Some juvenile fall chinook salmon, those rearing or overwintering in the reservoirs, could become stranded in pools when the reservoir elevations are reduced. These potential short-term and transitory adverse effects are difficult to quantify but could affect two year-classes.

Removal and Transition Period Effects on Adult Salmon. Three factors could influence the success of adult salmon and steelhead migration during the removal period and early in the transition period: suspended sediment concentrations, passage around breach and shoreline protection structures, and access into tributaries.

Suspended sediment concentrations would be elevated during drawdown (August through December work period) and then, with decreasing intensity, during subsequent spring freshets (April through June) for several years (the transition period). During removal operations, high concentrations of suspended sediment may cause increased delays and straying of fall migrants (fall chinook salmon and steelhead). Also, spring and summer chinook salmon could be delayed or could be caused to stray by turbidity events during subsequent spring freshets.

Upstream passage facilities at the dams would be inoperable during the fall/winter periods when dams are breached. This period encompasses most of the fall chinook and steelhead migrations. Specific actions would be implemented to ensure that adult fish move upstream. Under the current two-tiered, two-dam removal plan, the Corps recommends that adult fish be transported by truck around the construction reaches. Adults would probably be collected at Ice Harbor and Little Goose dams, respectively, during the two removal periods. Separating Lyons Ferry or

Tucannon River adults from adults destined for tributaries above Lower Granite would be of concern to NMFS during this trap and haul operation.

Adult movement past the former dam sites would probably not be impeded during the transition period or thereafter. Under current conditions in the lower Snake River, adults typically stop migrating when flows reach 170,000 cfs. Flows of this magnitude are expected to occur only for a brief period once every 5 years on average (Corps 1999c). The Corps would develop the breach areas around each dam such that river velocities up to the 170,000 cfs flow level would not impede adult passage. The following Corps' criteria for adult passage through the new channels are based on published information about fish behavior and modeled velocity conditions in the breach area (Corps 1999c [Appendix D]):

- Channel velocities below 1.5 meters per second (m/s) (5 feet per second [ft/s]) require no supplemental fish passage features.
- Higher channel velocities require features in the river that provide rest areas.
- As velocities increase above 1.5 m/s, the density of required rest areas increases.

The Corps will use model studies to determine the extent of appropriate rest structure layout during the next stage of the design process (Corps 1999c [Appendix D]).

In summary, NMFS finds that the greatest potential risk of reduced survival of juvenile and adult salmon and steelhead would occur during and immediately after the 2-year dam removal period. Risk would decrease each subsequent year as environmental conditions stabilize. The SR fall chinook salmon ESU appears to be most vulnerable to drawdown effects because at least part of both the juvenile and adult migration periods coincides with the August to December drawdown period. The risk to adults would be reduced by the Corps' planned trap-and-haul operation, but subsequent indirect effects of this operation are unknown. NMFS concludes that there is not sufficient information currently available to quantify these risks. If the Corps obtains congressional authorization to breach the lower Snake River dams, NMFS would recommend that the Corps develop detailed operations and demolition plans for the projects and consult with NMFS and USFWS on those plans.

9.7.3.1.2 Effects of Breaching on Sedimentation and Fluvial Geomorphology. Over time, breaching the four lower Snake River dams would restore riverine conditions to what is currently a series of impounded reservoirs. Rivers exist in dynamic equilibrium with the environmental forces that form them, including the hydrologic regime, underlying geology, and sediment supply. Whereas other multipurpose developments (e.g., flood control and irrigation) upstream from Lower Granite Dam have somewhat changed the hydrologic regime in the lower Snake River, sediment yields and channel-forming flows appear to be little changed (Corps 1999c

[Appendix H]).[4] These observations, combined with the fact that the lower Snake River is confined within a basalt gorge, lead NMFS to conclude that, following dam removal, a river greatly resembling the pre-dam Snake River would emerge. The rate at which this likely outcome would occur would depend on sediment transport and thus on river discharge and channel form, properties that are difficult to forecast with precision. The Corps predicts that the bulk of the morphological changes would occur during the first decade after dam removal, as sediment deltas in the reservoirs erode (Corps 1999c [Appendix H]).

Estimates of the amount of sediment stored in reservoirs upstream from Ice Harbor Dam range from 100 to 150 million cubic yards (Corps 1999c [Appendix H]), with the majority stored in Lower Granite Reservoir (72 to 96 million cubic yards). About half this stored sediment would be transported out of the Snake River basin within the first few years following breaching (Corps 1999c [Appendix H]). Much of the accumulated sediment that would remain currently covers areas that would become uplands after dam removal, where the erosive forces of the river would become slight to nonexistent. These deposits would be recolonized and stabilized by vegetation and could become relatively permanent features on the landscape. Sediments stored in the active channel would mobilize and be redeposited in accordance with their size relative to the erosive energy of the stream. Sand and finer particles would be readily mobilized and either move as a bedload or become suspended in the water column and move as part of the river's suspended sediment load. These small particles would be deposited in relatively quiescent areas, primarily along the river's shoreline, or would be transported through the Snake River to the Columbia River confluence and beyond. Gravel and larger particles would move primarily as bedload and be sorted and deposited in accordance with local conditions (shear stress). Large particles are the most difficult to move and would tend to dominate the fastest water as smaller particles were washed away. Bedload transport would virtually stop at Lake Wallula (Columbia River confluence), and a substantial sediment deposit would form along the shoreline downstream from the Snake River confluence and other quiescent and backwater areas between the confluence and McNary Dam (Corps 1999c, Appendix H). These deposits are expected to be 3 feet deep or less.

Erosion of the sediment body presently located in Lower Granite Reservoir would be severe near the face of the existing sediment delta (between RM 110 and RM 122). A single channel would rapidly emerge as the particles at its base were transported away and the channel rapidly cut upstream. This downcutting would leave portions of the sediment body perched above the active channel, forming steep banks. Subsequent high flows that fill the channel would flatten the banks. These effects would probably occur within 1 or 2 years of dam removal, assuming near-normal streamflow conditions. Due to the large sediment supply, the channel in and immediately downstream from this sediment body would be subject to the greatest changes in bedform, including tendencies to form islands and large bars.

After dam breaching, the annual sediment yield upstream from Lower Granite Dam would pass unimpeded through the lower river, replenishing gravels and adding to turbidity events. This

[4] Channel bedform changes almost continually over a wide range of discharges. However, as the product of the probability of occurrence and the channel-forming forces exerted, bank full discharge (or the 1.5- to 2-year return period flood) is generally accepted to represent the dominant channel-forming flow.

would add about 3 to 4 million cubic yards to the river's sediment load (Corps 1999c [Appendix H]). These effects would be permanent.

Suspended sediment concentrations in the lower Snake and Columbia rivers would also increase after breaching, as demonstrated during the 1992 partial drawdown test in Lower Granite Reservoir. Suspended sediment concentrations increased from a background level of 9.5 parts per million (ppm) to a high reading of 1,928 ppm. However, the highest concentrations occurred soon after drawdown and declined rapidly; most measurements were lower than 510 ppm (USFWS 1999). The Corps estimates that concentrations as high as 9,000 mg/l might occur immediately following breaching at Ice Harbor Dam (Corps 1999c).

Suspended sediment concentrations would be highest during the first few years following dam breaching and the exposure of the sediment body to the erosive force of the river. Annual peaks would occur immediately after breaching and drawdown operations (August to December) and then again during the spring freshet (April through June). This seasonal flushing would continue several years after removal, but with decreasing intensity (Corps 1999c).

Suspended sediment concentrations would increase permanently as upstream suspended sediment loads pass through the river. It is anticipated that within a decade after dam breaching operations were complete, suspended sediment loads in the affected reach would approximate incoming loads from the upper basin (Corps 1999c, Appendix H).

<u>Effects of Sedimentation and Changes in Fluvial Geomorphology on Juvenile Survival</u>. The expected increase in suspended sediment concentrations following dam breaching (between 2,000 and 9,000 milligrams per liter (mg/l) during part of the spring freshet), in each of several years after breaching could affect juvenile salmonid survival. Salmon and steelhead smolts are known to survive suspended sediment concentrations as high as 20,000 mg/l (Sigler et al. 1984). However, some researchers have observed juvenile salmon mortalities at suspended sediment concentrations as low as 500 mg/l (Waters 1995). Thus, some direct mortality of migrating juveniles is likely during peak suspended sediment events (corresponding with the rising limb of the spring freshet hydrograph). However, such effects would be transitory (a few weeks) and would only affect a fraction of several subsequent juvenile migrations. While the Corps has analyzed the chemical characteristics of some sediment cores, NMFS expects that a much more thorough sampling effort would be carried out before drawdown to ensure that resuspended sediments are not toxic or deleterious to aquatic life.

Given that increasing turbidity reduces the capture efficiencies of visually-oriented predators like smallmouth bass, northern pikeminnows, gulls, and terns (NMFS 2000f), predation rates would probably be reduced by post-drawdown increases in suspended sediment concentrations. However, this effect could be offset somewhat by an increased predator density (at least temporarily) following dam removal, as the assemblage of fishes now occupying the reservoirs vies to occupy smaller volumes of suitable habitat (Corps 1999c).

Effects of Sedimentation and Changes in Fluvial Geomorphology on Spawning Habitat. Two potential biological effects of the morphological changes likely to occur following breaching are increased spawning habitat in the mainstem Snake River, and passage barriers at tributary mouths.

In the short term, breaching activities would disrupt tailrace spawning habitat for fall chinook that currently occurs below Lower Granite and Little Goose dams. At the same time, new spawning habitat would emerge.

In the rapid erosion zone (RM 110 to RM 122) there is some risk that established redds would be subsequently scoured, buried, or dewatered as the channel form changes in the first few years following dam removal. Because few fish are expected to use this habitat during the breaching and transition period, such potential adverse effects are expected to be minor and short-term.

Mainstem spawning habitat would reemerge between RM 10 (the current site of Ice Harbor) to RM 140 (upper end of Lower Granite Reservoir) and would probably be enhanced by a plentiful sediment supply for decades following dam breaching. The Corps (1999c [Appendix H]) estimated that suitable fall chinook spawning habitat in the lower Snake River could increase from 226 acres under current conditions to 3,521 acres following breaching, an almost 16-fold increase. Although this would be a substantial increase in fall chinook spawning habitat, at the current depressed numbers of spawning adults, available spawning habitat is not limiting the population.

Currently accessible tributary habitat may become inaccessible due to the exposure of large sediment fans at the tributary mouths. During 30-plus years of impoundment, sediment has accumulated and formed deltas where tributaries enter the lower Snake River reservoirs. Following drawdown, these deltas would impede upstream fish passage until the streams move sediment back into the original riverbed or the sediment is moved by mechanical means. Schuck (1992) observed a large deposit of sediment at the mouth of Alpowa Creek during the 1992 Lower Granite Reservoir drawdown test and noted a vertical bedform at the mouth of this stream that would have been impassable to steelhead. Tributary sediment deltas are expected to erode rapidly, but human intervention may be necessary to ensure access to all suitable spawning habitat.

9.7.3.1.3 Estimated Juvenile Survival Following Transition Period. After a natural channel configuration has developed in the 210-km reach and riparian vegetation has become established, NMFS expects that juvenile survival rates will approximate the rates observed in free-flowing reaches above the head of Lower Granite pool. Estimates of survival from the Salmon River trap at Whitebird to Lower Granite Dam are available for wild spring chinook salmon during 1966 through 1968 (Raymond 1979) and for wild spring/chinook salmon and steelhead during 1993 through 1998 (Smith et al. 1998; Hockersmith et al. 1999; Smith et al. 2000). The estimates for both periods include survival through Lower Granite Reservoir. Those for the recent period also include survival past Lower Granite Dam. Using the methods described in Appendix A to factor out the reservoir and dam mortality, NMFS calculates an average per-km survival rate through the free-flowing stretch of 0.999689614 per km for spring chinook and 0.999656 per km for steelhead. Interannual variation was high (Appendix A). The average estimates can be expanded to survival through the entire 210-km reach, resulting in a mean reach survival of 92.2% for SR spring/summer chinook salmon and 93.0% for steelhead (Table 9.7-19). These estimates compare to a range of 85% to 95% estimated by the PATH team (Marmorek et al. 1998). The PATH estimates ranged from historical Whitebird trap estimates (95%) to combined Whitebird and Imnaha trap estimates for the period 1993 through 1996 (85%).

NMFS did not incorporate the Imnaha trap or other Salmon River traps into the estimates. Traps in the Salmon River above Whitebird were not used in estimates for the following reasons:

- The estimates are already captured in the Whitebird to Lower Granite estimate, because it includes fish from all of the tributaries caught at the upstream traps.

- The Whitebird estimate is through a river reach that is more similar to the reach below Lower Granite Dam (in terms of river width and depth and flow characteristics) than are the reaches further up in the tributaries. The Imnaha trap is in a tributary habitat that is more dissimilar to the reach below Lower Granite Dam than is the Whitebird trap.

- The upstream traps are closer to spawning areas, so survival rates from those traps probably represent a culling process that would be greater than that included in the survival rate below Whitebird. To elaborate, culling may result from size, degree of smoltification, or river stretches through which the smolts migrated. These stretches are likely to be more dissimilar among Lower Granite and tributary smolts than among Lower Granite and Whitebird smolts. Imnaha trap estimates were not used because the trap is closer to the spawning grounds than is the Whitebird trap.

To test the hypothesis that survival is lower in reaches closer to spawning grounds than in reaches farther downstream, survival of Whitebird and Imnaha releases was compared in the reach between each trap and Lower Granite Dam and in two reaches below Lower Granite Dam (Appendix A). Survival between the Imnaha trap and Lower Granite Dam, expressed as a per-km rate, was much lower than between the Whitebird trap and Lower Granite Dam, whereas survival estimates for the two traps were nearly identical when compared between Lower Granite Dam and Little Goose Dam, and between Little Goose Dam and Lower Monumental Dam. This suggests that after initial losses of fish occur, there are no inherent differences in smolt survival between stocks released at Imnaha and Whitebird. Thus, the Whitebird trap provides the best estimates of expected survival in downstream stretches of natural river.

The estimates of survival through the breached section of the Snake River can be combined with estimates of survival through the four lower Columbia River projects to derive an estimate of system survival after the drawdown transition period has passed. Estimates of SR spring/summer chinook survival through the four lower Columbia River projects are shown in

Table 9.7-1.[5] Inriver survival from McNary to Bonneville dams would average 66.4%. When survival through the free-flowing reach in the lower Snake River is combined with survival through the impounded reach in the lower Columbia River, system survival of SR spring/summer chinook salmon is expected to average 61.2% (Table 9.7-20). Using a similar method (and data shown in Table 9.7-1) for steelhead, system survival for juveniles from this ESU is expected to average 63% (Table 9.7-20).

Table 9.7-20. Estimates of juvenile survival for three Snake River ESUs following a transition period after breaching four Snake River dams.

ESU	Avg Survival/Km Through Free-Flowing Reach	Survival Through 210-km Reach After 4-Dam Breach	Lower River (MCN to BON) Survival	Total System Survival After 4-Dam Breach
SR spr/sum chinook salmon	99.9614%	92.2%	66.4%	61.2%
SR fall chinook				
Method A	99.78%	63.0%	37.7%	23.8%
Method B	99.95%	90.0%	37.7%	34.0%
SR Steelhead	99.9656%	93.0%	67.7%	63.0%

Empirical estimates of free-flowing reach survival for juvenile SR fall chinook salmon is more limited and difficult to interpret. The PATH participants used two methods to group and extrapolate recent PIT-tag survival estimates (Peters et al. 1999). The first (hereafter called Method A) results in a free-flowing survival rate of 0.9978 per km, and the second (Method B) in a rate of 0.9995 per km. NMFS finds that both methods are credible and that there is no basis for concluding that one better represents the best available scientific information than the other. Therefore, NMFS uses both methods and establishes a range of likely survival estimates. When expanded to the 210-km reach, Method A estimates an average survival of 63.0% versus 90.0% for Method B (Table 9.7-20). Using a method similar to that applied to SR spring/summer chinook salmon, and the data shown in Table 9.7-1 for the survival of fall chinook salmon through the lower Columbia reach, the system survival of juvenile Snake River fall chinook is expected to average 23.8% with Method A and 34% with Method B (Table 9.7-20).

NMFS has not estimated the survival of juvenile Snake River sockeye salmon through free-flowing river reaches or through the four lower Columbia River projects under the RPA. Based on the similar size and migration timing of juvenile sockeye salmon, yearling chinook salmon, and steelhead, it is likely that a four-dam breach will result in Snake River sockeye survival that is similar to that estimated for the other two spring migrating ESUs (approximately 60%, on

[5] NMFS assumes that juvenile fish would not be transported from McNary Dam if the Snake River dams are breached.

average). Breaching four dams in the Snake River will not change the estimates of juvenile survival for ESUs spawning outside of the Snake River basin, so NMFS applies the juvenile survival rates associated with the RPA.

9.7.3.1.4 Estimated Adult Survival Following Transition Period. After a natural channel configuration has developed in the 210-km reach and riparian vegetation has become established, NMFS expects that adult survival rates through the lower Snake River will approximate the rates observed in free-flowing reaches above the head of Lower Granite pool.

The PATH participants estimated free-flowing survival of wild SR spring/summer chinook salmon by applying the absolute difference in Bjornn's (1989) mean dam-count to redd-count ratios at Ice Harbor Dam for two periods, 1962 through 1968 and 1975 through 1988 (Marmorek et al. 1998). Ice Harbor was the furthest upstream hydroproject during the first period. The difference between the mean ratios for each period estimates the effect of the three dams that were constructed above Ice Harbor during the latter period (1975 through 1988). Extrapolating Bjornn's result over all four dams, the estimate of survival of adult spring/summer chinook salmon traversing the post-drawdown reach between the current location of the tailrace of Ice Harbor Dam and the head of Lower Granite pool would be 97% (i.e., 99% per-project). This method assumes that survival from the current location of the head of Lower Granite pool to the various spawning areas did not change between the two periods. In applying this method, NMFS assumes that survival through the four-dam lower Snake reach, as currently configured and operated, is equivalent to survival through that reach during the 1975 through 1988 period. In fact, recent reach survival studies indicate survival rates have improved with changes in FCRPS configuration and operations (NMFS 2000e), suggesting that this method may overestimate survival through a free-flowing lower Snake River reach if the dams were removed.

An alternative method is to evaluate the survival of radio-tagged adults through free-flowing reaches above Lower Granite Dam, in a manner similar to that used to estimate juvenile survival. Bjornn et al. (1995) estimated adult loss of spring chinook salmon from Ice Harbor Dam to reference points in tributaries to the Snake River above Lower Granite Dam. NMFS estimated survival from Ice Harbor to Lower Granite and adjusted total survival rates to derive estimates of survival through the free-flowing reach, using methods documented in Table 6.1-1. The resulting survival rate was 0.994 per km, equal to 88.2% (97% per-project) survival through the 210-km reach that would be affected by breaching four lower Snake River dams. In using this approach, NMFS made numerous assumptions to adjust the original empirical estimates of adult loss. NMFS also assumed that any delayed effects of passing eight dams before entering the free-flowing reach above Lower Granite Dam would be equivalent to the delayed effects of passing only four dams following breaching.

This second method may underestimate survival of adults through free-flowing river sections. In addition to consideration of the assumptions described above, comparison of the estimate of survival generated by the second method with estimates of survival under current conditions (Table 6.1-7) indicates that this method predicts lower adult survival under free-flowing conditions (88.2%) than under impounded conditions ($0.976^4 = 90.8\%$). Although adults travel through impounded sections of the Snake River at approximately the same speed as they travel through free-flowing reaches (e.g., Bjornn et al. 1998, NMFS 2000e), it is not clear that survival rates through impounded and unimpounded reaches are equivalent.

NMFS considers the best estimate of adult spring/summer chinook survival following breaching to be intermediate to estimates derived from the two methods described above. The survival rate expected to result from the RPA represents survival through an impounded reach with all possible improvements short of breaching. The estimate of adult survival, when the RPA is fully implemented, is 98% per project, intermediate to the survival rate estimated by the first and second methods (97% and 99% per project, respectively). Using the preferred method, expected survival of adult SR spring/summer chinook through the FCRPS, without breaching, is 85.5% (Table 9.7-2).

One advantage of the method used for estimating the survival of SR spring/summer chinook salmon is that it is directly applicable to other ESUs, whereas the other two methods are not. Therefore, estimates of adult survival for all ESUs are as described in Table 9.7-2. The expected survival rates are 74% for SR fall chinook salmon, 80.3% for steelhead, and 88.7% for SR sockeye salmon.

9.7.3.2 Analysis of Effects of Snake River Four-Dam Breach on Biological Requirements Over Full Life Cycle

Quantitative analyses were possible for three of the four Snake River ESUs that would be affected by breaching Snake River dams. Details of the analyses used to evaluate the effects of the proposed action on biological requirements over the full life cycle are described in Appendix A. Specifics of the analyses for each ESU are nearly identical to those described in Section 6.2.1. Results are summarized for the three Snake River ESUs in the following sections.

9.7.3.2.1 Snake River Spring/Summer Chinook Salmon

NMFS evaluated the same populations and used the same general approach as that described in Section 9.7.2.1. The necessary improvements in survival from average base period conditions were also as described in Section 9.7.2.1.

A key uncertainty associated with dam breaching is the effect that it will have on survival below Bonneville Dam (e.g., Marmorek and Peters 1998, Peters et al. 1999, Kareiva et al. 2000). Although it is likely that some actions called for by the RPA will improve fish conditions and survival below Bonneville Dam, NMFS conservatively assumed that there would be no effect of the proposed action (Section 6.3.1) or of the RPA (Section 9.7.2.1) on post-Bonneville survival, compared to average post-Bonneville survival during 1980 to 1999. That is, NMFS considered both the differential survival of transported fish (compared to nontransported fish; D) and the post-Bonneville delayed mortality of nontransported fish (EM hereafter) to be unchanged from the base period to the future under the proposed action and RPA.

In contrast, NMFS considered three alternatives for future post-Bonneville survival after breaching four Snake River dams. In each alternative, the differential post-Bonneville survival of transported fish is eliminated following breaching because NMFS assumes that transportation would cease. The alternatives apply different assumptions regarding the change in delayed mortality of nontransported fish following breaching.

In one alternative, NMFS assumed that delayed mortality of nontransported fish does not change after four Snake River dams are breached. With this alternative, the current estimate of EM is not important, since the calculated change in survival resulting from breaching will be the same whether EM is believed to be 0% or 74%. This alternative corresponds to two of the three PATH extra mortality hypotheses, which ascribe this mortality to causes other than the hydrosystem (Section 6.2.3.3).

In the second alternative, NMFS assumes that average 1980 to 1999 EM is between 71% (when coupled with D = 0.73) and 74% (when coupled with D = 0.63). This represents the PATH estimate of hydrosystem-caused, post-Bonneville mortality, when all extra mortality is believed to be caused by the hydrosystem. The estimate of 71% to 74% delayed mortality of nontransported fish represents the upper end of the range NMFS considered in this analysis (Section 6.2.3.3). This second alternative assumes that approximately half of this mortality is eliminated when four of the eight Snake River dams are breached, which corresponds to PATH's Hydro Hypothesis (Marmorek and Peters 1998; Wilson 2000).

The third alternative is identical to the second, except that it assumes that 100% of the delayed mortality of nontransported fish is eliminated. This assumption was included in the July 27, 2000, Draft Biological Opinion and incorrectly ascribed to the PATH Hydro Hypothesis (Wilson 2000). NMFS retains it because several agencies and organizations that commented on the July 27, 2000, Draft Biological Opinion expressed their opinion that this is the most likely assumption. Because all of these assumptions are essentially beliefs, based on little or no direct evidence, inclusion of the full range of opinions demonstrates the range of possible outcomes after breaching.

Details of the methods and results for each approach are included in Appendix A. A summary follows.

<u>No Change in Delayed Mortality of Nontransported Juveniles After Breaching</u>

NMFS estimated mean juvenile passage survival to Bonneville Dam during the base period, including differential post-Bonneville survival of transported fish (D=0.63 to D=0.73), using the two methods described in Section 6.3.1.3 and applied in Section 9.7.2.1. Although this first approach is not sensitive to assumptions regarding delayed mortality of nontransported fish, the assumption of 70% to 74% EM was applied to facilitate comparison with the other approaches. This resulted in a range of 11% to 13% juvenile survival. Juvenile survival to Bonneville following breaching was estimated at 61.2%, as described in Section 9.7.3.1.3 (Table 9.7-20). When the 70% to 74% delayed mortality assumption is applied to the survival to Bonneville, 16.8% juvenile survival is expected after breaching. The result is a 33% to 39% proportional juvenile survival improvement following breaching.

Adult passage survival during the 1980 to 1999 period was 82.5% (Table 9.7-2). Expected survival following breaching is 85.5% (Section 9.7.3.1.4). The result is a 3.7% proportional adult survival improvement following breaching. When the juvenile and adult survival improvements are combined, the overall effect of breaching four Snake River dams is a 38% to 44% proportional improvement (1.38 to 1.44 times average 1980 to 1999 survival).

This expected improvement is sufficient to result in a positive population growth rate under all assumptions considered in this analysis for six of the seven index stocks (Table 9.7-21). The Imnaha River index stock would continue to decline under the lowest estimate of lambda and would be stable under the highest estimate. Additional survival improvements are not required for any of the index stocks under the most optimistic assumptions. Additional improvements ranging from 5% to 56% would be required with the higher estimate of necessary changes.

Delayed Mortality of Nontransported Juveniles is Reduced by Half After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. Only half of the delayed mortality estimate was applied in this approach, resulting in 39% juvenile survival following breaching. A 220% to 236% proportional survival improvement is associated with breaching under this alternative. Under this assumption, population growth would be positive for all index stocks, and no additional survival changes would be required (Table 9.7-22).

Delayed Mortality of Nontransported Juveniles is Eliminated After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. No delayed mortality was applied in this approach, resulting in 61.2% juvenile survival following breaching. A 403% to 427% proportional survival improvement is associated with breaching under this approach. Under this assumption, population growth would be positive for all index stocks, and no additional survival changes would be required (Table 9.7-23).

Comparison to PATH

These results are similar to those of PATH (Marmorek et al. 1998, Peters and Marmorek 2000), with respect to the higher likelihood of meeting approximations of the survival and recovery

Table 9.7-21. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change after breaching four dams, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four dams. This analysis assumes no change in delayed mortality of nontransported fish after breaching four of eight dams.

Spawning Aggregation	1980-Current Lambda Low[1]	1980-Current Lambda High[2]	Expected Survival Change Low[3]	Expected Survival Change High[4]	Expected Lambda Low[5]	Expected Lambda High[6]	Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years Low[7]	5% Extinction Risk In 100 Years High[8]	50% Recovery In 48 Years or Lambda = 1.0 Low[7]	50% Recovery In 48 Years or Lambda = 1.0 High[8]
ESU Aggregate	0.82	0.91	1.38	1.44	0.88	0.99	1.40	1.46	1.07	1.78
Index Stocks:										
Bear Valley/Elk Creeks	1.02	1.03	1.38	1.44	1.09	1.11	0.48	0.73	0.53	0.84
Imnaha River	0.88	0.92	1.38	1.44	0.95	1.00	0.56	1.09	0.84	1.56
Johnson Creek	1.01	1.03	1.38	1.44	1.09	1.12	0.48	0.73	0.47	0.78
Marsh Creek	0.99	1.00	1.38	1.44	1.06	1.08	0.49	0.83	0.65	1.05
Minam River	0.93	1.02	1.38	1.44	1.01	1.11	0.48	1.06	0.56	1.20
Poverty Flats	0.99	1.02	1.38	1.44	1.07	1.12	0.48	0.73	0.49	0.84
Sulphur Creek	1.04	1.05	1.38	1.44	1.11	1.14	0.56	0.99	0.52	0.82
Additional Aggregations:										
Alturas Lake Ck	0.75	0.75	1.38	1.44	0.80	0.81	N/A	N/A	2.57	2.69
American R	0.91	0.91	1.38	1.44	0.98	0.99	N/A	N/A	1.07	1.12
Big Sheep Ck	0.85	0.88	1.38	1.44	0.92	0.93	N/A	N/A	1.24	1.48
Beaver Cr	0.95	0.95	1.38	1.44	1.02	1.03	N/A	N/A	0.86	0.90
Bushy Fork	0.98	0.98	1.38	1.44	1.05	1.06	N/A	N/A	0.76	0.79
Camas Cr	0.92	0.92	1.38	1.44	0.99	1.00	N/A	N/A	1.00	1.04
Cape Horn Cr	1.05	1.05	1.38	1.44	1.13	1.14	N/A	N/A	0.55	0.58
Catherine Ck	0.78	0.85	1.38	1.44	0.84	0.85	N/A	N/A	1.44	2.17
Catherine Ck N Fk	0.92	0.92	1.38	1.44	0.99	1.00	N/A	N/A	1.00	1.05
Catherine Ck S Fk	0.80	0.80	1.38	1.44	0.85	0.86	N/A	N/A	1.92	2.01
Crooked Fork	1.00	1.00	1.38	1.44	1.07	1.08	N/A	N/A	0.70	0.73
Grande Ronde R	0.77	0.84	1.38	1.44	0.83	0.84	N/A	N/A	1.52	2.28
Knapp Cr	0.89	0.89	1.38	1.44	0.96	0.97	N/A	N/A	1.17	1.22
Lake Cr	1.06	1.06	1.38	1.44	1.14	1.15	N/A	N/A	0.54	0.56
Lemhi R	0.98	0.98	1.38	1.44	1.05	1.06	N/A	N/A	0.77	0.81
Lookingglass Ck	0.72	0.79	1.38	1.44	0.78	0.79	N/A	N/A	1.93	3.05
Loon Ck	1.00	1.00	1.38	1.44	1.08	1.09	N/A	N/A	0.68	0.71
Lostine Ck	0.87	0.90	1.38	1.44	0.94	0.94	N/A	N/A	1.10	1.35
Lower Salmon R	0.92	0.92	1.38	1.44	0.98	1.00	N/A	N/A	1.02	1.07
Lower Valley Ck	0.92	0.92	1.38	1.44	0.99	1.00	N/A	N/A	0.99	1.03
Moose Ck	0.94	0.94	1.38	1.44	1.01	1.02	N/A	N/A	0.90	0.94
Newsome Ck	1.03	1.03	1.38	1.44	1.10	1.12	N/A	N/A	0.61	0.64
Red R	0.91	0.91	1.38	1.44	0.98	0.99	N/A	N/A	1.06	1.11
Salmon R E Fk	0.94	0.94	1.38	1.44	1.01	1.02	N/A	N/A	0.92	0.96
Salmon R S Fk	1.06	1.06	1.38	1.44	1.14	1.15	N/A	N/A	0.54	0.56
Secesh R	0.98	0.98	1.38	1.44	1.05	1.06	N/A	N/A	0.77	0.81
Selway R	0.91	0.91	1.38	1.44	0.98	0.99	N/A	N/A	1.04	1.09
Sheep Cr	0.80	0.80	1.38	1.44	0.86	0.87	N/A	N/A	1.89	1.97
Upper Big Ck	0.97	0.97	1.38	1.44	1.04	1.05	N/A	N/A	0.80	0.84
Upper Salmon R	0.90	0.90	1.38	1.44	0.97	0.98	N/A	N/A	1.09	1.14
Upper Valley Ck	1.03	1.03	1.38	1.44	1.11	1.12	N/A	N/A	0.60	0.63
Wallowa Ck	0.86	0.86	1.38	1.44	0.92	0.93	N/A	N/A	1.36	1.42
Wenaha R	0.84	0.90	1.38	1.44	0.90	0.91	N/A	N/A	1.09	1.56
Whitecap Ck	0.90	0.90	1.38	1.44	0.97	0.98	N/A	N/A	1.09	1.14
Yankee Fork	0.88	0.88	1.38	1.44	0.95	0.96	N/A	N/A	1.21	1.27
Yankee West Fk	0.99	0.99	1.38	1.44	1.06	1.07	N/A	N/A	0.73	0.76

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
[3] Low represents estimation of juvenile survival improvement based on a comparison of PATH retrospective and prospective (A2) results.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS results.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for index stocks) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate.

Table 9.7-22. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change after breaching four dams, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four dams. This analysis assumes high delayed mortality of nontransported fish in the base period, with half of it removed after breaching four of eight dams.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.82	0.91	3.20	3.36	1.05	1.18	0.60	0.63	0.46	0.77
Index Stocks:										
Bear Valley/Elk Creeks	1.02	1.03	3.20	3.36	1.30	1.33	0.09	0.31	0.10	0.36
Imnaha River	0.88	0.92	3.20	3.36	1.14	1.21	0.10	0.47	0.15	0.67
Johnson Creek	1.01	1.03	3.20	3.36	1.32	1.37	0.09	0.31	0.09	0.34
Marsh Creek	0.99	1.00	3.20	3.36	1.27	1.30	0.09	0.36	0.12	0.45
Minam River	0.93	1.02	3.20	3.36	1.23	1.36	0.09	0.46	0.10	0.52
Poverty Flats	0.99	1.02	3.20	3.36	1.31	1.36	0.09	0.31	0.09	0.36
Sulphur Creek	1.04	1.05	3.20	3.36	1.34	1.37	0.10	0.43	0.10	0.35
Additional Aggregations:										
Alturas Lake Ck	0.75	0.75	3.20	3.36	0.97	0.98	N/A	N/A	1.11	1.16
American R	0.91	0.91	3.20	3.36	1.18	1.19	N/A	N/A	0.46	0.48
Big Sheep Ck	0.85	0.88	3.20	3.36	1.11	1.12	N/A	N/A	0.53	0.64
Beaver Cr	0.95	0.95	3.20	3.36	1.24	1.25	N/A	N/A	0.37	0.39
Bushy Fork	0.98	0.98	3.20	3.36	1.27	1.29	N/A	N/A	0.33	0.34
Camas Cr	0.92	0.92	3.20	3.36	1.20	1.21	N/A	N/A	0.43	0.45
Cape Horn Cr	1.05	1.05	3.20	3.36	1.37	1.38	N/A	N/A	0.24	0.25
Catherine Ck	0.78	0.85	3.20	3.36	1.02	1.03	N/A	N/A	0.62	0.93
Catherine Ck N Fk	0.92	0.92	3.20	3.36	1.20	1.21	N/A	N/A	0.43	0.45
Catherine Ck S Fk	0.80	0.80	3.20	3.36	1.03	1.04	N/A	N/A	0.83	0.87
Crooked Fork	1.00	1.00	3.20	3.36	1.30	1.31	N/A	N/A	0.30	0.31
Grande Ronde R	0.77	0.84	3.20	3.36	1.00	1.01	N/A	N/A	0.65	0.98
Knapp Cr	0.89	0.89	3.20	3.36	1.16	1.17	N/A	N/A	0.50	0.53
Lake Cr	1.06	1.06	3.20	3.36	1.37	1.39	N/A	N/A	0.23	0.24
Lemhi R	0.98	0.98	3.20	3.36	1.27	1.28	N/A	N/A	0.33	0.35
Lookingglass Ck	0.72	0.79	3.20	3.36	0.94	0.95	N/A	N/A	0.83	1.31
Loon Ck	1.00	1.00	3.20	3.36	1.30	1.32	N/A	N/A	0.29	0.31
Lostine Ck	0.87	0.90	3.20	3.36	1.13	1.14	N/A	N/A	0.47	0.58
Lower Salmon R	0.92	0.92	3.20	3.36	1.19	1.20	N/A	N/A	0.44	0.46
Lower Valley Ck	0.92	0.92	3.20	3.36	1.20	1.21	N/A	N/A	0.42	0.44
Moose Ck	0.94	0.94	3.20	3.36	1.23	1.24	N/A	N/A	0.39	0.40
Newsome Ck	1.03	1.03	3.20	3.36	1.33	1.35	N/A	N/A	0.26	0.28
Red R	0.91	0.91	3.20	3.36	1.18	1.19	N/A	N/A	0.46	0.48
Salmon R E Fk	0.94	0.94	3.20	3.36	1.22	1.23	N/A	N/A	0.39	0.41
Salmon R S Fk	1.06	1.06	3.20	3.36	1.37	1.39	N/A	N/A	0.23	0.24
Secesh R	0.98	0.98	3.20	3.36	1.27	1.28	N/A	N/A	0.33	0.35
Selway R	0.91	0.91	3.20	3.36	1.19	1.20	N/A	N/A	0.45	0.47
Sheep Cr	0.80	0.80	3.20	3.36	1.04	1.05	N/A	N/A	0.81	0.85
Upper Big Ck	0.97	0.97	3.20	3.36	1.26	1.27	N/A	N/A	0.34	0.36
Upper Salmon R	0.90	0.90	3.20	3.36	1.17	1.19	N/A	N/A	0.47	0.49
Upper Valley Ck	1.03	1.03	3.20	3.36	1.34	1.35	N/A	N/A	0.26	0.27
Wallowa Ck	0.86	0.86	3.20	3.36	1.12	1.13	N/A	N/A	0.58	0.61
Wenaha R	0.84	0.90	3.20	3.36	1.09	1.10	N/A	N/A	0.47	0.67
Whitecap Ck	0.90	0.90	3.20	3.36	1.17	1.18	N/A	N/A	0.47	0.49
Yankee Fork	0.88	0.88	3.20	3.36	1.15	1.16	N/A	N/A	0.52	0.54
Yankee West Fk	0.99	0.99	3.20	3.36	1.28	1.30	N/A	N/A	0.31	0.33

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
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Table 9.7-23. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change after breaching four dams, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four dams. This analysis assumes high delayed mortality of nontransported fish in the base period, with all of it removed after breaching four of eight dams.

							Additional Change In Survival Needed to Achieve:			
Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.82	0.91	5.03	5.27	1.15	1.30	0.38	0.40	0.29	0.49
Index Stocks:										
Bear Valley/Elk Creeks	1.02	1.03	5.03	5.27	1.43	1.46	0.04	0.20	0.04	0.23
Imnaha River	0.88	0.92	5.03	5.27	1.26	1.34	0.04	0.30	0.06	0.43
Johnson Creek	1.01	1.03	5.03	5.27	1.46	1.51	0.04	0.20	0.03	0.21
Marsh Creek	0.99	1.00	5.03	5.27	1.39	1.43	0.04	0.23	0.05	0.29
Minam River	0.93	1.02	5.03	5.27	1.37	1.51	0.04	0.29	0.04	0.33
Poverty Flats	0.99	1.02	5.03	5.27	1.45	1.52	0.04	0.20	0.04	0.23
Sulphur Creek	1.04	1.05	5.03	5.27	1.48	1.51	0.04	0.27	0.04	0.23
Additional Aggregations:										
Alturas Lake Ck	0.75	0.75	5.03	5.27	1.07	1.08	N/A	N/A	0.70	0.74
American R	0.91	0.91	5.03	5.27	1.30	1.32	N/A	N/A	0.29	0.31
Big Sheep Ck	0.85	0.88	5.03	5.27	1.22	1.24	N/A	N/A	0.34	0.41
Beaver Cr	0.95	0.95	5.03	5.27	1.37	1.38	N/A	N/A	0.24	0.25
Bushy Fork	0.98	0.98	5.03	5.27	1.41	1.42	N/A	N/A	0.21	0.22
Camas Cr	0.92	0.92	5.03	5.27	1.32	1.34	N/A	N/A	0.27	0.29
Cape Horn Cr	1.05	1.05	5.03	5.27	1.51	1.53	N/A	N/A	0.15	0.16
Catherine Ck	0.78	0.85	5.03	5.27	1.12	1.14	N/A	N/A	0.40	0.60
Catherine Ck N Fk	0.92	0.92	5.03	5.27	1.32	1.34	N/A	N/A	0.27	0.29
Catherine Ck S Fk	0.80	0.80	5.03	5.27	1.14	1.15	N/A	N/A	0.53	0.55
Crooked Fork	1.00	1.00	5.03	5.27	1.43	1.45	N/A	N/A	0.19	0.20
Grande Ronde R	0.77	0.84	5.03	5.27	1.11	1.12	N/A	N/A	0.42	0.62
Knapp Cr	0.89	0.89	5.03	5.27	1.28	1.29	N/A	N/A	0.32	0.33
Lake Cr	1.06	1.06	5.03	5.27	1.52	1.54	N/A	N/A	0.15	0.15
Lemhi R	0.98	0.98	5.03	5.27	1.40	1.42	N/A	N/A	0.21	0.22
Lookingglass Ck	0.72	0.79	5.03	5.27	1.04	1.05	N/A	N/A	0.53	0.84
Loon Ck	1.00	1.00	5.03	5.27	1.44	1.46	N/A	N/A	0.19	0.20
Lostine Ck	0.87	0.90	5.03	5.27	1.25	1.26	N/A	N/A	0.30	0.37
Lower Salmon R	0.92	0.92	5.03	5.27	1.32	1.33	N/A	N/A	0.28	0.29
Lower Valley Ck	0.92	0.92	5.03	5.27	1.33	1.34	N/A	N/A	0.27	0.28
Moose Ck	0.94	0.94	5.03	5.27	1.36	1.37	N/A	N/A	0.25	0.26
Newsome Ck	1.03	1.03	5.03	5.27	1.47	1.49	N/A	N/A	0.17	0.18
Red R	0.91	0.91	5.03	5.27	1.31	1.32	N/A	N/A	0.29	0.30
Salmon R E Fk	0.94	0.94	5.03	5.27	1.35	1.36	N/A	N/A	0.25	0.26
Salmon R S Fk	1.06	1.06	5.03	5.27	1.52	1.54	N/A	N/A	0.15	0.15
Secesh R	0.98	0.98	5.03	5.27	1.40	1.42	N/A	N/A	0.21	0.22
Selway R	0.91	0.91	5.03	5.27	1.31	1.33	N/A	N/A	0.28	0.30
Sheep Cr	0.80	0.80	5.03	5.27	1.15	1.16	N/A	N/A	0.52	0.54
Upper Big Ck	0.97	0.97	5.03	5.27	1.39	1.40	N/A	N/A	0.22	0.23
Upper Salmon R	0.90	0.90	5.03	5.27	1.30	1.31	N/A	N/A	0.30	0.31
Upper Valley Ck	1.03	1.03	5.03	5.27	1.48	1.50	N/A	N/A	0.16	0.17
Wallowa Ck	0.86	0.86	5.03	5.27	1.23	1.25	N/A	N/A	0.37	0.39
Wenaha R	0.84	0.90	5.03	5.27	1.21	1.22	N/A	N/A	0.30	0.43
Whitecap Ck	0.90	0.90	5.03	5.27	1.30	1.31	N/A	N/A	0.30	0.31
Yankee Fork	0.88	0.88	5.03	5.27	1.27	1.28	N/A	N/A	0.33	0.35
Yankee West Fk	0.99	0.99	5.03	5.27	1.42	1.43	N/A	N/A	0.20	0.21

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
[3] Low represents estimation of juvenile survival improvement based on a comparison of PATH retrospective and prospective (A2) results.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS results.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for index stocks) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

indicator metrics with breaching than with a modeling scenario approximating the RPA. PATH results also indicated that the degree of difference between the actions depends largely on assumptions regarding delayed mortality of both transported and nontransported fish. PATH analyses differed from the analysis described above in at least one significant way. PATH considered a wide range of differential delayed mortality estimates, rather than the D = 0.63 to D = 0.73 range included in the analyses described above. Half of the PATH analyses included estimates of D that were considerably lower (approximately D = 0.35), which means that for these PATH analyses survival following breaching would increase substantially more than the amount estimated above, simply as a result of eliminating transportation. As described in Section 6.2.3.3, NMFS finds that available empirical information does not support such low estimates of differential post-Bonneville survival. As a result of this and other factors, PATH concluded that the average results for all assumptions considered by PATH indicated that breaching four Snake River dams would easily meet survival and recovery indicator metrics. NMFS results indicate that the ability to meet survival and recovery indicator metrics depends largely on assumptions regarding the degree to which delayed mortality of nontransported fish is reduced—assumptions that cannot be validated with available information.

9.7.3.2.2 Snake River Fall Chinook Salmon

NMFS evaluated the same aggregate population and used the same general approach as that described in Section 9.7.2.2. The necessary improvements in survival from average base period conditions were also as described in Section 9.7.2.2.

A key uncertainty associated with dam breaching is the effect that it will have on survival below Bonneville Dam. NMFS evaluated the same three assumptions described in Section 9.7.3.2.1 regarding the effect of breaching on delayed mortality of nontransported smolts. Although the rationale and conflicting opinions on potential effects have mainly been developed for SR spring/summer chinook salmon, most can also be applied to SR fall chinook salmon.

In one alternative, NMFS assumed that delayed mortality of nontransported fish does not change after four Snake River dams are breached. With this alternative, the current estimate of EM is not important, since the calculated change in survival resulting from breaching will be the same whether EM is believed to be 0% or 19%. This alternative corresponds to two of the three PATH extra mortality hypotheses for SR spring/summer chinook salmon, which ascribe this mortality to causes other than the hydrosystem (Section 6.2.3.3).

In the second alternative, NMFS assumes that average base period EM is 19% (Section 6.2.3.3). This represents the mean PATH estimate of hydrosystem-caused, post-Bonneville mortality, when D=0.24, and all extra mortality is believed to be caused by the hydrosystem. The estimate of 19% delayed mortality of nontransported fish represents the upper end of the range NMFS considered in this analysis (Section 6.2.3.3). This second alternative assumes that approximately half of this mortality is eliminated when four of the eight Snake River dams are breached, which corresponds to PATH's SR spring/summer chinook Hydro Hypothesis (Marmorek and Peters 1998, Wilson 2000).

The third alternative is identical to the second, except that it assumes that 100% of the delayed mortality of nontransported fish is eliminated. This assumption was included in the July 27, 2000, Draft Biological Opinion and incorrectly ascribed to the PATH Hydro Hypothesis (Wilson 2000). NMFS retains it because several agencies and organizations that commented on the July 27, 2000, Draft Biological Opinion expressed their opinion that this is the most likely assumption. Because all of these assumptions are essentially beliefs, based on little or no direct evidence, inclusion of the full range of opinions demonstrates the range of possible outcomes after breaching.

Details of the methods and results for each approach are included in Appendix A. A summary follows.

<u>No Change in Delayed Mortality of Nontransported Juveniles After Breaching</u>

NMFS estimated mean juvenile passage survival to Bonneville Dam during the base period, including differential post-Bonneville survival of transported fish (D = 0.24), using the method described in Section 6.3.2.3 and applied in Section 9.7.2.3. NMFS has not estimated differential post-Bonneville survival of SR fall chinook and the estimate of 0.24 represents one of the alternative PATH estimates that NMFS considers most consistent with the limited empirical information (Section 6.2.3.3). It is used in the absence of an alternative empirically based estimate. Although this first approach is not sensitive to assumptions regarding delayed mortality of nontransported fish, the assumption of 19% EM was applied to facilitate comparison with the other approaches. This resulted in 14% juvenile survival. Juvenile survival to Bonneville following dam breaching was estimated at 23.8% to 34.0%, as described in Section 9.7.3.1.3 (Table 9.7-20). When the 19% delayed mortality assumption is applied to the survival to Bonneville, 19% to 28% juvenile survival is expected after breaching. The result is a 36% to 95% proportional juvenile survival improvement following breaching.

Adult passage survival during the base period was 71% (Table 9.7-2). Expected survival following breaching is 74% (Section 9.7.3.1.4). The result is a 4.2% proportional adult survival improvement following breaching. When the juvenile and adult survival improvements are combined, the overall effect of breaching four Snake River dams is a 64% to 185% proportional improvement (1.64 to 2.85 times average base period survival).

This expected improvement is sufficient to result in a positive population growth rate under the most optimistic assumptions, but the population would continue to decline under the lowest estimate of lambda (Table 9.7-24). No additional survival improvements are required under the most optimistic assumptions. An additional 32% improvement (1.32 times average 1980 to 1996 survival) would be required with the higher estimate of necessary changes.

Table 9.7-24. Snake River fall chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from breaching four dams, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four dams.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
No Change In Nontransport Delayed Mortality:										
Aggregate SR Fall Chinook	0.87	0.92	1.63	2.87	0.98	1.18	0.43	0.86	0.60	1.32
Nontransport Delayed Mortality Reduced By Half:										
Aggregate SR Fall Chinook	0.87	0.92	1.82	3.20	1.01	1.22	0.38	0.77	0.54	1.18
Nontransport Delayed Mortality Completely Eliminated:										
Aggregate SR Fall Chinook	0.87	0.92	2.01	3.54	1.03	1.25	0.35	0.70	0.49	1.07

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents estimation of juvenile survival improvement based on PATH retrospective and prospective (A2) results and change in harvest rate based on PATH.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS and harvest rate change based on PSC.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

Delayed Mortality of Nontransported Juveniles Is Reduced by Half After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. Only half of the delayed mortality estimate was applied in this approach, resulting in 21.5% to 30.8% juvenile survival following breaching. A 282% to 420% proportional survival improvement is associated with breaching under this alternative. Under this assumption, population growth would be positive, and no additional survival changes would be required under the most optimistic assumptions. However, an additional 18% survival improvement (1.18 times average 1980 to 1996 survival) would be necessary under the high estimate of necessary survival changes.

Delayed Mortality of Nontransported Juveniles Is Eliminated After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. No delayed mortality was applied in this approach, resulting in 23.8% to 34% juvenile survival following breaching. A 301% to 454% proportional survival improvement is associated with breaching under this approach. Under this assumption, population growth would be positive for all index stocks, and no additional survival changes would be required under the most optimistic assumptions. However, an additional 7% survival improvement (1.07 times average 1980 to 1996 survival) would be necessary under the high estimate of necessary survival changes.

Comparison to PATH

These results are similar to those of PATH (Peters et al. 1999), with respect to the higher likelihood of meeting approximations of the survival and recovery indicator metrics with breaching than with a modeling scenario approximating the RPA, when similar D assumptions are applied. PATH results also indicated that the degree of difference between the actions depends largely on assumptions regarding delayed mortality of both transported and nontransported fish. Under PATH's average assumptions, however, breaching met approximations of the 1995 FCRPS Biological Opinion's jeopardy standards, without the need for any additional survival improvements. NMFS' results indicate that this is likely to happen only if delayed mortality of nontransported fish is currently high and if breaching four dams significantly reduces that delayed mortality.

Both PATH and NMFS' analysis may be somewhat pessimistic regarding the effects of breaching, since the potential additional spawning areas created by breaching had little analytical effect in PATH's analysis and were not analytically considered in this analysis. PATH assumed that most of the newly created habitat would be inferior to that currently available, so did not model a change in carrying capacity until estimated capacity of the currently available habitat was exceeded. This meant that additional spawning habitat did not improve survival until the population was near the recovery level. One organization (Save Our Wild Salmon) commented that NMFS needed to consider the benefits of additional spawning areas in the analysis. This is considered qualitatively in Section 9.7.3.1.2.

9.7.3.2.3 Snake River Steelhead

NMFS evaluated the same spawning aggregations and used the same general approach as that described in Section 9.7.2.6. The necessary improvements in survival from average base period conditions were also as described in Section 9.7.2.6.

A key uncertainty associated with dam breaching is the effect that it will have on survival below Bonneville Dam. NMFS evaluated the same three assumptions described in Section 9.7.3.2.1 regarding the effect of breaching on delayed mortality of nontransported smolts. Although the rationale and conflicting opinions on potential effects have mainly been developed for SR spring/summer chinook salmon, most can also be applied to SR steelhead.

In one alternative, NMFS assumed that delayed mortality of nontransported fish does not change after four Snake River dams are breached. With this alternative, the current estimate of EM is not important, since the calculated change in survival resulting from breaching will be the same whether EM is believed to be 0% or 74%. This alternative corresponds to two of the three PATH extra mortality hypotheses for SR spring/summer chinook salmon, which ascribe this mortality to causes other than the hydrosystem (Section 6.2.3.3).

In the second alternative, NMFS assumes that average base period EM is equivalent to that described for SR spring/summer chinook in Section 9.7.3.2.1. This second alternative assumes that approximately half of this mortality is eliminated when four of the eight Snake River dams are breached, which corresponds to PATH's SR spring/summer chinook Hydro Hypothesis (Marmorek and Peters 1998, Wilson 2000).

The third alternative is identical to the second, except that it assumes that 100% of the delayed mortality of nontransported fish is eliminated. This assumption was included in the July 27, 2000, Draft Biological Opinion and incorrectly ascribed to the PATH Hydro Hypothesis (Wilson 2000). NMFS retains it because several agencies and organizations that commented on the July 27, 2000, Draft Biological Opinion expressed their opinion that this is the most likely assumption. Because all of these assumptions are essentially beliefs, based on little or no direct evidence, inclusion of the full range of opinions demonstrates the range of possible outcomes after breaching.

Details of the methods and results for each approach are included in Appendix A. A summary follows.

No Change in Delayed Mortality of Nontransported Juveniles After Breaching

NMFS assumed that the change from juvenile passage survival to Bonneville Dam during the base period, including differential post-Bonneville survival of transported fish (D=0.52 to D = 0.58), to juvenile survival associated with current operations was the same as that which was estimated for SR spring/summer chinook (Section 6.3.6). NMFS estimated this change as a 24% to 32% proportional improvement. NMFS also estimated changes in harvest rates (Section 6.3.6).

In addition, breaching represents a further survival change from current conditions. Although this first approach is not sensitive to assumptions regarding delayed mortality of nontransported fish, the average SR spring/summer chinook assumption of 73% EM was applied to the estimate of current juvenile survival to facilitate comparison with the other approaches. This resulted in 14% current juvenile survival. Juvenile survival to Bonneville following dam breaching was estimated at 63%, as described in Section 9.7.3.1.3 (Table 9.7-20). When the 73% delayed mortality assumption is applied to the survival to Bonneville, 17.3% juvenile survival is expected after breaching. The result is a 24.5% proportional juvenile survival improvement from current conditions following breaching.

Adult passage survival during the base period was 77.3% (Table 9.7-2). Expected survival following breaching is 80.3% (Section 9.7.3.1.4). The result is a 3.9% proportional adult survival improvement following breaching. When the change from average base period juvenile survival to current juvenile survival, the change from current juvenile survival to juvenile survival after breaching, harvest reductions, and the adult survival improvement are combined, the overall effect of breaching four Snake River dams is a 65% to 77% proportional improvement for A-run steelhead and a 79% to 92% improvement for B-run steelhead.

This expected improvement is not sufficient to produce a positive population growth rate, and additional survival improvements ranging from 25% to 278% (1.25 to 3.78 times average base period survival) would still be necessary to meet survival and recovery indicator criteria (Table 9.7-25).

Delayed Mortality of Nontransported Juveniles Is Reduced by Half After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. Only half of the delayed mortality estimate was applied in this approach, resulting in 40.1% juvenile survival following breaching. A 285% to 311% proportional survival improvement is associated with breaching under this alternative. Under this assumption, the highest estimates of population growth would be positive, and the lowest would remain negative (Table 9.7-25). No additional survival changes would be required under the most optimistic assumptions. However, an additional 18% to 63% survival improvement (1.18 to 1.63 times average base period survival) would be necessary under the high estimate of necessary survival changes.

Delayed Mortality of Nontransported Juveniles Is Eliminated After Breaching

All aspects of this approach were identical to the first, except for the level of delayed mortality applied to juvenile survival following breaching. No delayed mortality was applied in this approach, resulting in 63% juvenile survival following breaching. A 503% to 544% proportional survival improvement is associated with breaching under this approach. Under this assumption, population growth would be positive except under the low assumptions for B-run steelhead. No additional survival changes would be required for A-run steelhead under all assumptions or for B-run steelhead under the most optimistic assumptions (Table 9.7-25). However, an additional 4% survival improvement (1.04 times average base period survival) would be necessary for B-run steelhead under the high estimate of necessary survival changes.

9.7.3.2.4 Snake River Sockeye Salmon

Because the abundance of SR sockeye salmon is extremely low, the risk of extinction cannot be calculated using the methods that NMFS employs in this biological opinion. However, current risk is undoubtedly very high.

Table 9.7-25. Snake River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from breaching four dams and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after breaching four Snake River dams.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
No Change In Nontransport Delayed Mortality:										
ESU Aggregate	0.72	0.83	1.72	1.84	0.80	0.94	0.81	1.69	1.38	3.14
A-Run Aggregate	0.74	0.85	1.65	1.77	0.82	0.96	0.74	1.52	1.25	2.74
A-Run Pseudopopulation[9]	0.74	0.85	1.65	1.77	0.82	0.96	0.83	1.68	1.25	2.74
B-Run Aggregate	0.74	0.84	1.79	1.92	0.81	0.92	1.03	2.19	1.68	3.78
B-Run Pseudopopulation[10]	0.74	0.84	1.79	1.92	0.81	0.92	1.09	2.31	1.68	3.78
Nontransport Delayed Mortality Reduced By Half:										
ESU Aggregate	0.72	0.83	4.01	4.28	0.94	1.11	0.35	0.73	0.59	1.35
A-Run Aggregate	0.74	0.85	3.84	4.11	0.97	1.13	0.32	0.65	0.54	1.18
A-Run Pseudopopulation[9]	0.74	0.85	3.84	4.11	0.97	1.13	0.36	0.72	0.54	1.18
B-Run Aggregate	0.74	0.84	4.17	4.46	0.93	1.05	0.44	0.94	0.72	1.63
B-Run Pseudopopulation[10]	0.74	0.84	4.17	4.46	0.93	1.05	0.47	0.99	0.72	1.63
Nontransport Delayed Mortality Completely Eliminated:										
ESU Aggregate	0.72	0.83	6.29	6.72	1.03	1.21	0.22	0.46	0.38	0.86
A-Run Aggregate	0.74	0.85	6.03	6.44	1.06	1.24	0.20	0.42	0.34	0.75
A-Run Pseudopopulation[9]	0.74	0.85	6.03	6.44	1.06	1.24	0.23	0.46	0.34	0.75
B-Run Aggregate	0.74	0.84	6.55	6.99	0.99	1.13	0.28	0.60	0.46	1.04
B-Run Pseudopopulation[10]	0.74	0.84	6.55	6.99	0.99	1.13	0.30	0.63	0.46	1.04

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents SR spring/summer chinook Low estimate.
[4] High represents SR spring/summer chinook High estimate.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Pseudopopulation is 10% of A-run aggregate abundance.
[10] Pseudopopulation is 33% of B-run aggregate abundance.

Due to the extreme low abundance of SR sockeye salmon in recent years, this ESU has not been used in passage survival studies. Therefore, NMFS has not estimated natural system survival or total system survival associated with breaching four Snake River dams for this ESU. Assuming that juvenile mortality in the action area is similar to that of other yearling migrants, dam breaching has the potential to increase action-area survival substantially if delayed mortality is currently high and if it is largely eliminated by breaching four of the eight FCRPS dams that sockeye must pass. Because the extinction risk for SR sockeye is most likely greater than that for SR steelhead and SR spring/summer chinook, additional survival improvements may also be needed for SR sockeye. If, on the other hand, delayed mortality is currently low or if there is no change in delayed mortality following breaching, dam breaching will result in action-area survival similar to the RPA. In this case, substantial survival improvements in addition to breaching would also be needed.

Because a quantitative analysis was not possible for this species, it is difficult to place the effects of the hydrosystem following a four-dam breach in the context of other factors influencing this ESU's survival and recovery. Other factors also affect elements of critical habitat and thus contribute to this ESU's high risk of extinction (summarized in Section 4.1 and Appendix A) and have been discussed in previous sections.

9.7.3.2.5 Eight Other ESUs

Because eight of the ESUs addressed in this biological opinion are distributed downstream of the Snake River dams, the effect of dam breaching would be identical to that of the RPA for UCR spring chinook, LCR chinook, UWR chinook, UCR steelhead, MCR steelhead, LCR steelhead, UWR steelhead, and CR chum salmon. One possible exception may be possible water quality changes, which could affect downstream stocks in an unquantifiable manner.

9.7.3.2.6 Summary—Effects of Snake River Four-Dam Breach on Biological Requirements Over Full Life Cycle

Breaching four Snake River dams is expected to have little or no effect on eight of the ESUs considered in this biological opinion because they do not pass through the lower Snake River. For these ESUs, the effect of dam breaching is identical, or nearly so, to that of the RPA. For the four Snake River ESUs that would be affected by dam breaching, the effect of this action, relative to the RPA, is determined almost entirely by delayed mortality assumptions, as described in previous sections.

The primary biological issue regarding breaching is the extent to which breaching four Snake River dams is likely to modify post-Bonneville survival of Snake River ESUs. If post-Bonneville survival improves significantly after breaching, this option is biologically superior to the RPA and has the potential to recover the four Snake River ESUs, even without additional offsite mitigation (Table 9.7-26). However, if the principal effect is constrained to the area that would be modified above Bonneville Dam, breaching represents only a marginal improvement

Table 9.7-26. Estimated percentage of additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after breaching four Snake River dams. Low and High estimates are based on a range of assumptions, as described in the text. Three assumptions regarding the effect of breaching on delayed mortality of nontransported fish are shown to demonstrate the influence of this assumption on results. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the RPA, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

Spawning Aggregation	Needed Survival Change After Implementing Hydrosystem Component of RPA (From Table 9.7-17)		Needed Survival Change if no Change in Non-Transport Delayed Mortality After Breaching (Whether Current Level is High or Low)		Needed Survival Change if Non-Transport Delayed Mortality is Currently High and is Reduced by Half After Breaching		Needed Survival Change if Non-Transport Delayed Mortality is Currently High and is Completely Eliminated After Breaching	
	Low	High	Low	High	Low	High	Low	High
Snake River Spring/Summer Chinook								
Aggregate ESU	46	89	40	78	0	0	0	0
Bear Valley/Elk Creeks	0	0	0	0	0	0	0	0
Imnaha River	26	66	0	56	0	0	0	0
Johnson Creek	0	0	0	0	0	0	0	0
Marsh Creek	0	12	0	5	0	0	0	0
Minam River	0	28	0	20	0	0	0	0
Poverty Flats	0	0	0	0	0	0	0	0
Sulphur Creek	0	5	0	0	0	0	0	0
Alturas Lake Ck	168	186	157	169	11	16	0	0
American R	11	19	7	12	0	0	0	0
Big Sheep Ck	29	58	24	48	0	0	0	0
Beaver Cr	0	0	0	0	0	0	0	0
Bushy Fork	0	0	0	0	0	0	0	0
Camas Cr	4	11	0	4	0	0	0	0
Cape Horn Cr	0	0	0	0	0	0	0	0
Catherine Ck	50	131	44	117	0	0	0	0
Catherine Ck N Fk	4	12	0	5	0	0	0	0
Catherine Ck S Fk	101	114	92	101	0	0	0	0
Crooked Fork	0	0	0	0	0	0	0	0
Grande Ronde R	58	142	52	128	0	0	0	0
Knapp Cr	22	30	17	22	0	0	0	0
Lake Cr	0	0	0	0	0	0	0	0
Lemhi R	0	0	0	0	0	0	0	0
Lookingglass Ck	102	225	93	205	0	31	0	0
Loon Ck	0	0	0	0	0	0	0	0
Lostine Ck	15	44	10	35	0	0	0	0
Lower Salmon R	7	14	2	7	0	0	0	0
Lower Valley Ck	3	10	0	3	0	0	0	0
Moose Ck	0	0	0	0	0	0	0	0
Newsome Ck	0	0	0	0	0	0	0	0

Table 9.7-26 (Continued). Estimated percentage of additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after breaching four Snake River dams. Low and High estimates are based on a range of assumptions, as described in the text. Three assumptions regarding the effect of breaching on delayed mortality of nontransported fish are shown to demonstrate the influence of this assumption on results. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the RPA, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

Spawning Aggregation	Needed Survival Change After Implementing Hydrosystem Component of RPA (From Table 9.7-17)		Needed Survival Change if no Change in Non-Transport Delayed Mortality After Breaching (Whether Current Level is High or Low)		Needed Survival Change if Non-Transport Delayed Mortality is Currently High and is Reduced by Half After Breaching		Needed Survival Change if Non-Transport Delayed Mortality is Currently High and is Completely Eliminated After Breaching	
	Low	High	Low	High	Low	High	Low	High
Red R	10	18	6	11	0	0	0	0
Salmon R E Fk	0	2	0	0	0	0	0	0
Salmon R S Fk	0	0	0	0	0	0	0	0
Secesh R	0	0	0	0	0	0	0	0
Selway R	8	15	3	9	0	0	0	0
Sheep Cr	97	110	89	97	0	0	0	0
Upper Big Ck	0	0	0	0	0	0	0	0
Upper Salmon R	13	21	9	14	0	0	0	0
Upper Valley Ck	0	0	0	0	0	0	0	0
Wallowa Ck	42	51	36	42	0	0	0	0
Wenaha R	14	66	9	56	0	0	0	0
Whitecap Ck	14	22	9	14	0	0	0	0
Yankee Fork	26	35	21	27	0	0	0	0
Yankee West Fk	0	0	0	0	0	0	0	0
Snake River Fall Chinook								
Aggregate	0	44	0	32	0	18	0	7
Snake River Steelhead								
ESU Aggregate	58	260	38	214	0	35	0	0
A-Run Aggregate	44	214	25	174	0	18	0	0
A-Run Pseudopopulation	44	214	25	174	0	18	0	0
B-Run Aggregate	92	333	68	278	0	63	0	4
B-Run Pseudopopulation	92	333	68	278	0	63	0	4

over the RPA, and additional improvements through off-site mitigation would still be required. As described in previous sections, NMFS considers empirical information bearing on the question of delayed mortality of nontransported fish to be lacking and information related to differential delayed mortality of transported fish to be very limited. The RPA includes a substantial research effort to help resolve the issue and built-in check points to evaluate new research results with respect to possible future modification of the RPA.

9.7.4 RPA Conclusions

The analysis in the preceding sections of this biological opinion forms the basis for NMFS' conclusions as to whether this RPA for operation of the FCRPS and BOR projects satisfies the standards of the ESA, Section 7(a)(2). To do so, the Action Agencies must ensure that the RPA does not jeopardize the continued existence of any listed species or destroy or adversely modify their designated critical habitat. Section 4 of this opinion defines the biological requirements and the current status of each of the 12 listed salmonid species; Section 5 evaluates the relevance of the environmental baseline to each species' current status; Section 9 details the likely effects of the RPA, both on individuals of the species in the action area and on the listed population as a whole across its range and life-cycle; and Section 7 considers cumulative effects of reasonably certain non-Federal actions within the action area. Based on this background information and analysis, NMFS draws its conclusions about the effects of the operation of the FCRPS and BOR projects, as described in this RPA, on the survival and recovery of 12 listed salmonid ESUs.

As discussed in Section 1.3 of this biological opinion, NMFS must now determine whether the species can be expected to survive with an adequate potential for recovery under the effects of the RPA, the environmental baseline and any cumulative effects, and considering measures for survival and recovery specific to other life stages. A relatively large amount of information, with a substantial amount of quantitative data (i.e., based on empirical observations) is available for ESUs such as SR spring/summer chinook salmon. For other ESUs, such as SR sockeye salmon, primarily qualitative information is available, based on the best professional judgment of knowledgeable scientists. Despite an increasing trend toward a more quantitative understanding of the status of each stock and ESU, critical uncertainties limit NMFS' ability to project future conditions and effects. As a result, there are currently no hard and fast numerical indices available for any of these stocks on which NMFS can base its determination about jeopardy or adverse modification of critical habitat, the Section 7(a)(2) standards. Ultimately, for all 12 ESUs, NMFS must make qualitative judgements based upon the best available quantitative and qualitative information for each species.

9.7.4.1 General RPA Conclusions For All ESUs

In Section 8 of this biological opinion, NMFS concludes that four ESUs will not be jeopardized by the proposed action (UWR and LCR chinook salmon and UWR and LCR steelhead). The RPA will have no adverse effects beyond those described in the proposed action, so NMFS concludes that these ESUs will not be jeopardized by the RPA. In Section 8, however, NMFS also concludes that eight ESUs will be jeopardized by the proposed action. Juvenile and adult mortality in the action area will be substantial, and critical habitat elements, such as water quality and (in the case of CR chum salmon) spawning habitat, will be adversely modified. NMFS concluded that the proposed action was not specific enough regarding measures to improve survival and avoid adverse modification of critical habitat in the action area and that performance standards for guiding improvements were not specific enough and were not tied to biological requirements throughout the life cycle.

Section 8 also indicated that the effects of the proposed action, when combined with anticipated survival improvements in other life stages, were not sufficient to ensure survival and recovery of these eight ESUs. Some additional survival improvements, beyond those considered in analyses of effects, were considered likely to occur as a result of Federal conservation measures related to habitat improvements and hatchery reforms described generally in the Basinwide Recovery Strategy. NMFS concluded, however, that the degree to which these measures will sufficiently augment survival improvements from implementing the proposed action and will ensure a high likelihood of survival and moderate-to-high likelihood of recovery of each ESU is uncertain. In order to conclude that the strategy of progress on non-Federal actions described in the Basinwide Recovery Strategy would provide survival improvements needed to avoid jeopardy, NMFS required a more reliable expectation of progress.

The RPA remedies these two primary shortcomings of the proposed action:

- Measures to improve survival in the action area, specified in detail in Section 9.6.1, are expected to result in higher survival in the action area than would be expected under the proposed action (Section 9.7.1). These measures are guided by explicit action-area performance standards and are integrated with life-cycle performance standards (Section 9.2). Measures also provide specific remedies for adverse modification of critical habitat, such as a gas-abatement program to reduce adverse modification of water quality.

- Section 9.2 of the RPA specifies that the Action Agencies will ensure implementation of enough offsite mitigation to achieve NMFS' estimate of the needed additional survival improvement. Specifics for implementing elements of the Basinwide Recovery Strategy as the Action Agencies' offsite mitigation program are included in Sections 9.6.2 through 9.6.4. In addition, the certainty that the RPA will achieve the survival improvements is increased by the RPA's rigorous evaluation process, by which RPA actions and ESU performance are assessed throughout the RPA's implementation (see Sections 9.4 and 9.5). The RPA thereby greatly increases NMFS' ability to rely on implementation of the non-Federal conservation measures described in the Basinwide Recovery Strategy.

The increased reliability of implementing the Basinwide Recovery Strategy measures, together with other ongoing Federal measures for survival and recovery specific to other life stages and the improved survival that will result from the hydropower measures of this RPA, ensure that each of the eight ESUs will have a high likelihood of survival and a moderate-to-high likelihood of recovery. NMFS' conclusions for all 12 listed ESUs are specified in the following sections.

9.7.4.2 Specific RPA Conclusions

9.7.4.2.1 Snake River Spring/Summer Chinook Salmon

After reviewing the current status of SR spring/summer chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of SR spring/summer chinook salmon or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of SR spring/summer chinook salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.2 Snake River Fall Chinook Salmon

After reviewing the current status of SR fall chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, NMFS concludes that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of SR fall chinook salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.3 Upper Columbia River Spring Chinook Salmon

After reviewing the current status of UCR spring chinook salmon and its factors for decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of UCR spring chinook salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.4 Upper Willamette River Chinook Salmon

Salmonids in the UWR chinook salmon ESU spawn and rear in tributaries that enter the Columbia River downstream from all FCRPS dams. The only effects of operation of the FCRPS on this ESU are potential habitat degradation in the estuary and plume. The magnitude of these effects is uncertain compared to other factors influencing the status of this species. Tables 6.3-13 and 9.7-18 indicate that factors other than the FCRPS limit this ESU's potential for survival and recovery. Therefore, after reviewing the current status of UWR chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA, and cumulative effects, NMFS concludes that the RPA, like the proposed action (see Section 8), is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

9.7.4.2.5 Lower Columbia River Chinook Salmon

As noted in Section 6.2, this ESU is distributed primarily in spawning and rearing areas below Bonneville Dam. The key effects on this species within the action area, summarized in Sections 6.2.9 and 9.7.1, include passage mortality of juveniles and adults from a limited number of spawning aggregations through one dam and reservoir (Bonneville Dam). For the portion of the ESU that was observed to spawn once in the Ives Island area, access to, and the quantity and quality of, that spawning habitat will be affected by FCRPS flow regulation. Tables 6.3-13 and 9.7-18 indicate, however, that factors other than the FCRPS limit this ESU's potential for survival and recovery. Therefore, after reviewing the current status of LCR chinook salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA, and cumulative effects, NMFS concludes that the RPA, like the proposed action, is not likely to jeopardize the continued existence of LCR chinook salmon or to destroy or adversely modify its designated critical habitat.

9.7.4.2.6 Snake River Steelhead

After reviewing the current status of SR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of SR steelhead when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.7 Upper Columbia River Steelhead

After reviewing the current status of UCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of UCR steelhead when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.8 Middle Columbia River Steelhead

After reviewing the current status of MCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of MCR steelhead when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.9 Upper Willamette River Steelhead

Salmonids in the UWR steelhead ESU spawn and rear in tributaries that enter the Columbia River downstream from all FCRPS dams. The only effects of operation of the FCRPS on this ESU are potential habitat degradation in the estuary and plume. The magnitude of these effects is uncertain compared to other factors influencing the status of this species. Tables 6.3-13 and 9.7-18 indicate that factors other than the FCRPS limit this ESU's potential for survival and recovery. Therefore, after reviewing the current status of UWR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA, and cumulative effects, NMFS concludes that the RPA, like the proposed action, is not likely to jeopardize the continued existence of LCR chinook salmon or to destroy or adversely modify its designated critical habitat.

9.7.4.2.10 Lower Columbia River Steelhead

As discussed in Section 6.2, this ESU is distributed primarily in spawning and rearing areas below Bonneville Dam. The key effects on this species within the action area, summarized in Sections 6.2.9 and 9.7.1, include passage mortality of juveniles and adults from a limited number of spawning aggregations through one dam and reservoir (Bonneville Dam). Tables 6.3-13 and 9.7-18 indicate that factors other than the FCRPS limit this ESU's potential for survival and recovery. Therefore, after reviewing the current status of LCR steelhead and the factors for its decline, the environmental baseline in the action area, the effects of the RPA, and cumulative effects, NMFS concludes that the RPA, like the proposed action, is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat.

9.7.4.2.11 Columbia River Chum Salmon

After reviewing the current status of CR chum salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, for the component of this ESU that migrates above Bonneville Dam, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements (particularly those affecting critical spawning habitat) of CR chum salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

9.7.4.2.12 Snake River Sockeye Salmon

After reviewing the current status of SR sockeye salmon and the factors for its decline, the environmental baseline in the action area, the effects of the RPA (particularly as described in Sections 9.7.1 and 9.7.2), and cumulative effects, NMFS concludes that the RPA is not likely to jeopardize the continued existence of this ESU or to destroy or adversely modify its designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described above. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of enough offsite mitigation that will be targeted to meet the biological requirements of SR sockeye salmon when combined with other elements of the RPA and the conservation measures anticipated in other life stages described in the Basinwide Recovery Strategy.

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